Health Effects Institute

HEI Annual Conference 2024

Abstracts

Listed alphabetically by presenter (underscored)

Key:

HEI	***HEI-funded Investigator***
HEI energy	***HEI Energy-funded Investigator***
RB	***Walter A. Rosenblith New Investigator Award Recipient***
JW	***Jane Warren Award Recipient***

HEI energy

Temporal Distributions of Preproduction Emission Sources from Oil and Gas Operations

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Unconventional oil and gas development (UOGD) in the Marcellus production region is a source of ozone (O_3) precursors such as nitrogen oxides (NOx) and Volatile Organic Compounds (VOCs). Emissions from oil and gas emission sources have complex temporal patterns. This work describes the spatial and temporal allocation of NOx from preproduction sources such as hydraulic fracturing and drilling.

Emissions for the Marcellus Shale from hydraulic fracturing and drilling in 2023 were obtained using the framework described in the EPA 2020 Nonpoint Oil and Gas Emission Estimation Tool and spatial and temporal distributions data from Enverus. Two emission scenarios were developed for the region. The first, consistent with the EPA Oil and Gas Tool's approach, distributes annual county-level emissions to all state active wells, assuming continuous year-round emissions. The second allocates emissions to wells fractured and drilling for that year, assuming a 2-week emission period.

Spatially and temporally allocating drilling and hydraulic fracturing emissions, while keeping total emissions constant, returned emission rates at specific sites that are up to 3 orders of magnitude higher than annual average county-level emissions, creating ozone hotspots. Mitigating these hotspots can be part of plans used to attain ozone National Ambient Air Quality Standards (NAAQS).

Spatially and temporally allocated emission rates can differ by multiple orders of magnitude compared to annual average county-level emissions, suggesting that spatial and temporal allocation of NOx emissions may have a significant impact on predicted ozone formation in the Marcellus.

Workshop on post combustion carbon capture amine solvent degradation monitoring and control: key findings and recommendations

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Post-combustion carbon dioxide capture technology has the potential to significantly reduce anthropogenic carbon dioxide emissions, but there are valid questions about implications for public health if deployed. While electrification alternatives are available for some sectors (e.g., power generation and heating), carbon capture may need to play a meaningful role in decarbonizing difficult to electrify industries. Amine solvents are one of the most widely used post-combustion carbon capture materials globally. However there is incomplete understanding and public knowledge of the possible releases of amines and their degradation products – a potentially meaningful source of criteria and hazardous pollutants. With fewer than thirty unique commercial point source carbon capture facilities operational worldwide and proprietary data limitations, information on amines loss/degradation in full-scale applications is limited. No standards or emissions monitoring requirements have been established in the United States. Still, project investments are moving forward. If not properly managed and avoided, the creation and potential release of toxic breakdown products like nitrosamines may pose serious hazards to the public near capture facilities and the sustainability of the industry through time. Such risk and solutions may not be broadly represented in regulatory and permitting programs, meaning that while options to select appropriate solvents and to implement engineered controls exist, they may not be widely utilized. As deployment advances, lack of measurement, control, or regulation of amine emissions, or lack of their enforcement, could lead to emissions and formation of probable human carcinogens. The poster will present the findings of a 2024 workshop of leading global experts on post combustion carbon capture amine solvent degradation monitoring and control, which include recommendations for U.S. Department of Energy, U.S. Environmental Protection Agency, state permitting entities, and operators.

RB

The Accra Birth Cohort (ABC): Investigating the impact of prenatal air pollution exposure on adverse birth outcomes and infant respiratory infections

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Background and objective: Existing evidence suggests that children born to mothers who are chronically exposed to air pollution are at higher risk of being born too small or too early, decreasing their chances of survival and threatening future health of survivors. Yet, in growing cities in sub-Saharan Africa (SSA), where urbanization is raising air pollution levels from diverse sources, prenatal and early-life exposures and their impacts on maternal and child health are less well characterized. To fill this gap, we established the Accra Birth Cohort (ABC) to quantify the effects of chronic maternal and early prenatal exposures to $PM_{2.5}$, black carbon (BC), and NO_2 on birth outcomes as well as lower respiratory infections in infants.

Methods: Between June 2023 and May 2024, ~3200 pregnant women were recruited across 30 health facilities located within the Greater Accra Metropolitan Area (GAMA). Maternal residential addresses were geocoded, and individual, household, and clinical data were gathered at baseline and during follow-up in the third trimester. Birth outcomes, including preterm birth and birthweight were documented. The infants are being followed bi-weekly/monthly for up to 18 months to document episodes of respiratory tract infections. Air pollutants exposures are estimated using existing high-resolution spatiotemporal land use regression models.

Preliminary results: The average maternal age was 28.8 (range:18-45) years with 87% below age 35. About 16% primarily cooked with biomass and 43% were anemic at baseline. Three percent had miscarriage/still birth and 6% delivered preterm. Of 2,430 births, the mean birthweight was 3,058g (IQR: 2735-3400) and with10% were with low birthweight.

Conclusion: As SSA experiences rapid urban growth and high environmental pollution, the ABC study aims to inform effective public health strategies and policy frameworks to enhance child health and survival in the region.

Cancer risk associated with inhalation exposure to PAHs and VOCs generated during grilling processes

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Background and objectives: inhalation and alimentary exposure to polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) associated with grilling processes and grilled dishes may pose health risks. Numerous epidemiological studies indicate a positive association between these sources of exposure and increased cancer risk in non-smokers.

Methods and approach: Four types of grills/fuels were used: lump charcoal (LC), charcoal briquettes (CB), liquid propane (LP) and electric grills (E). Respirable fraction (PM_4) samples were gathered both during the combustion of the fuel and while grilling vegetables and meat dishes. Gilian GilAir aspirators equipped with SKC Higgins-Dewell samplers (quartz filters for PAHs and sorption tubes for VOCs) were placed above the grill fireplace, in the control area and as personal samplers. 15 PAH congeners were extracted from the solid and gas phases and measured by HPLC. Extracted VOCs samples were analyzed by GC-FID chromatography. For 2 grills (CB and E) and the control area continuous measurement of PM and TVOC concentrations was also conducted. A probabilistic risk model was developed to estimate the incremental lifetime cancer risk (ILCR) in individuals exposed to inhalation of PAHs and VOCs.

Results and findings: The ILCR related to exposure to PAHs and VOCs congeners indicated an unacceptable level for grilling using CB (the highest values for professional chefs). PAHs concentrations while grilling food were highest when preparing meat on CB - 382,020 ng/m^3, and lowest when grilling meat on LP - 1,442 ng/m^3. VOCs emissions from LC grilling were 130 times higher compared to LP grilling. In the case of using LC, and especially CB, in most of the scenarios considered, the ILCR associated with exposure to PAHs and VOCs significantly exceeds (by up to 2 orders of magnitude) the level of $1*10^{-4}$ considered acceptable by the WHO.

Conclusions and interpretation: CB is most dangerous due to inhalation of PAHs from the grilling processes, especially when preparing meat dishes. The risk of inhaling barbecue exhausts was greater than $1*10^{-3}$, suggesting a high probability of cancer from exposure to PAHs.

HEI energy

Long-Term Trends of Hazardous Air Pollutants Over the Marcellus Shale Region: A Deep Learning-Enhanced Modeling Approach

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The Marcellus Shale region has experienced rapid expansion of unconventional oil and gas development (UOGD), affecting local air quality through emissions of hazardous air pollutants (HAPs) and criteria air pollutants (CAPs) such as NOx, and $PM_{2.5}$. However, the long-term trends of these pollutants remain insufficiently characterized, limiting assessments of their environmental and public health impacts. To address this gap, we applied a deep-learning-enhanced chemical transport modeling system (DeepCTM) designed to efficiently estimate historical and future HAPs concentrations while closely mimicking the traditional chemical transport models (CTMs) like Comprehensive Air Quality Model with Extensions (CAMx).

DeepCTM is trained to replicate the physical and chemical processes simulated by CAMx, significantly reducing computational costs while maintaining high accuracy. To enhance its predictive performance, we conducted multi-year CAMx simulations (2008, 2014, and 2019) along with multiple extreme emission control scenarios to capture a wide range of air quality conditions. These high-resolution (4 km × 4 km) CAMx outputs were used as training datasets, allowing DeepCTM to learn the complex relationships between emissions, meteorology, and pollutant concentrations. The well-trained DeepCTM model achieved high correlations (R^2 = 0.95–0.99) with CAMx simulations for HAPs daily average concentration, demonstrating its capability to accurately reproduce CAMx-modeled HAPs, including benzene, toluene, ethylbenzene, xylenes, naphthalene, and butadiene.

In this study, we present 20-year trends (2002-2021) of HAPs concentrations over the Marcellus Shale region using DeepCTM predictions, identifying key spatial and temporal variations driven by UOGD activities, meteorological changes, and emission control measures. The results provide valuable insights into the effectiveness of air quality management policies and strategies for mitigating emissions from oil and gas operations. By combining AI-driven modeling with traditional CTMs, this approach offers a scalable and computationally efficient framework for long-term air quality assessments, applicable to other regions impacted by energy production activities.

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An Analysis of Water Quality in the Oldest Hydrocarbon Basin in the USA

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Background & Objectives: This study examines the relationship between groundwater contamination and unconventional oil and development (UOGD) in Southwestern PA (SWPA), one of the most intensively drilled portions of the Marcellus Shale basin. Water samples were gathered from 97 private groundwater wells, springs, and streams to evaluate potential UOGD-related contamination for groundwaters near: 1. Chloride hotspots, identified in previous research; 2. UOGD wastewater impoundments that were removed by regulatory authorities; 3. Wellpad spills and brownfield cleanup sites.

Methods & Approach: Geochemical and radiation analyses were conducted on the samples to test for the presence of various dissolved constituents including salts, heavy metals, dissolved gases, and radioactive species. A household survey and literature review were simultaneously conducted to: A. better understand household demographics, well characteristics, and land use practices of sampled homes; and B. to explore for potential public health risks from exposure to analytes found to be above safe drinking water thresholds in our water sampling analysis. Statistical analyses and regression modeling were conducted to compare median values between treatment and control sites and to evaluate relationships between distance from UOG wells, hotspots, impoundments and spills and species concentrations.

Results & Findings: Concentrations of potassium, radon, and copper were higher in groundwater wells in some areas associated with UOGD compared to control areas but differences in geology and land use (coal mining) across the region may also explain these slightly elevated concentrations. Concentrations of iron increased closer to spill sites. Of these contaminants, only iron and radon were sometimes found to be above EPA established or proposed drinking water standards. Radon is associated with deleterious health effects, but iron is regulated by the EPA for aesthetic purposes.

Conclusions & Interpretation: Overall, very few instances of contamination above established or proposed drinking water standards were observed. The most common constituent above an EPA proposed MCL was radon gas. Radon commonly derives from natural processes, UOGD, and agricultural processes.

Wildfire-specific fine particulate matter and perinatal outcomes in Australia

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Background and objectives: Air pollution is associated with adverse birth outcomes, although less is known for wildfire smoke. We conducted three related studies to evaluate associations between wildfire-related fine particles ($PM_{2.5}$) and birth outcomes.

Methods and approach: 1) We systematically reviewed 8 databases to identify relevant epidemiological studies. Screening, data extraction, and risk of bias assessment were performed by pairs of independent reviewers. 2) We quantified the fractions of fire emissions injected above the planetary boundary layer and the impact of plume injection fractions on daily wildfire-related $PM_{2.5}$ in key Australian cities (2009-2020). We used tested two approaches, one using Integrated Monitoring and Modelling System and a novel approach based on NASA MISR observations and a random forest, machine learning model. 3) **We** applied distributed lag Cox regression models with spatial clustering to estimate short-term effects of wildfire-specific $PM_{2.5}$ and its carbonaceous components on perinatal outcomes for a multicentre cohort of 9743 births during wildfire seasons for six cities in New South Wales, Australia.

Results and findings: 1) **We screened** 28,549 records, identifying 31 for inclusion. Findings indicate methodological heterogeneity between studies. Results suggest harm from wildfire smoke for several adverse outcomes (e.g., birthweight reduction, preterm birth).

2) Characterization of plume injection heights greatly affects estimates of smoke $PM_{2.5}$, especially during severe wildfire seasons. Our random forest model successfully reproduced daily injected fire emission fluxes against MISR observations (R^2=0.88).

3) Adjusted hazard ratios (aHRs) at lag 0-6 days showed associations with several outcomes (e.g., stillbirth: 1.40; 95 % CI: 1.11, 1.78 per 10mg/m^3 $PM_{2.5}$; 4.57; 95 % CI: 1.96, 10.68 per 1mg/m^3 black carbon).

Conclusions and interpretation: Our findings summarize the literature on wildfire smoke and birth outcomes, provide new methods and improved estimates of wildfire $PM_{2.5}$, and indicate associations between wildfire-specific $PM_{2.5}$ and its carbonaceous components with perinatal outcomes.

Efficacy of HEPA filtration air purifiers at reducing blood pressure for residents living next to highways

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Background and Objectives: Airborne particulate matter (PM; ultrafine and black carbon PM) from motor vehicles is a cause of cardiovascular risk. Blood pressure (BP) is one indicator of this risk. We sought to assess efficacy of in-home air purifiers at reducing BP in healthy adults living adjacent to highways.

Methods and Approach: We conducted a double blind, randomized crossover trial with one month each of high efficiency particulate arrestance (HEPA) vs. sham filtration that was completed by 156 participants. Brachial and central BP were measured at the start and end of each month. Linear mixed models were used to compare the mean change in BP between the HEPA and sham filtration periods. We included a random intercept to account for within-participant correlation of repeated BP measurements, sequence and period effects. Models were adjusted for participantâ€™s age, sex, BP measurement at start of each intervention period, number of hours spent indoors a week prior to the BP measurement, and outdoor temperature and perceived stress score at the time of the BP measurement.

Results and Findings: The overall results yielded no significant differences in BP between the HEPA and sham filtration periods. However, in a subgroup analysis participants with elevated SBP (i.e., brachial > 120 or central > 110 mmHg) at the start of the intervention period had a significant 3.2 mmHg difference in favor of HEPA filtration (P = 0.03). A similar 3.1 mmHg net difference was observed for central SBP (P = 0.02). Only small, clinically unimportant and statistically insignificant, reductions in DBP were observed.

Conclusions and Interpretation: We controlled for most time invariant and time varying confounders, showing that air purifier use results in reductions in SBP for people with elevated SBP. Air purifiers may be a viable intervention for at risk populations living near motor vehicle traffic.

HEI energy

Developing spatially and temporally varying emission inventory in the Marcellus Shale

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Ambient concentrations of air pollutants in oil and gas production regions have strong spatial and temporal variations. Conventional emission estimation methods, such as the Oil and Gas Tool developed by the U.S. Environmental Protection Agency, reports annual average emissions at the county level and does not capture finer scale spatial and temporal variations. Detailed spatial and temporal allocations of emissions are important in characterizing spatial and temporal patterns of human exposures.

This work developed detailed emission inventories of methane, ethane, volatile organic compounds (VOCs), and Nitrogen oxides (NOx) in the Marcellus oil and gas production region for the year 2023. Emissions from preproduction, production, and midstream operations were simulated and spatially and temporally allocated. The emission inventory was spatially aggregated at the level of grid cells (4km by 4km) and counties, and at a temporal resolution in one hour, although the underlying emission estimation methods could be used to generate inventories at other spatial and temporal aggregation levels.

Preliminary analyses focused on seven grid cells with a variety of production and emission characteristics. For methane emissions, the maximum hourly emission rates are typically several times the mean emission rates, with greater relative variability in dry regions. Ethane and VOC emissions showed higher temporal variations per grid cell than other inventoried emissions, especially in regions with wells with high liquid unloading emissions. The ratio of maximum to mean hourly VOC emissions per grid cell varied from 3 to over 50. In contrast, NOx emissions, primarily from continuously operating compressors, remained relatively stable. Temporal variations of emissions were smaller at county levels than at grid cell levels. The complex spatial and temporal patterns of emission allocations developed in this work improves the accuracy of ability to generate exposure estimates based on localized and intermittent emission sources from unconventional oil and gas development.

HEI energy

Hydrocarbon emission modeling from oil and gas sources in the Permian Basin to understand regional level emission event activities

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Multiple automated gas chromatographs (autoGCs), established by Texas Commission on Environmental Quality (TCEQ) in the Permian Basin oil and gas production region in west Texas, measure and quantify over 40 different hydrocarbon species including ethane, propane, and butanes. Hourly concentration measurements from the autoGCs were used to assess the frequency and temporal distributions of emission events from oil and gas facilities in the region. AutoGC measurements show a strong diurnal pattern. Elevated concentrations were mostly observed during nighttime hours and could be due to either meteorological conditions or large emission events. To better understand the cause of nighttime concentration enhancements, detailed emission modeling and dispersion modeling were performed for this region. A nested modeling domain of 120 km by 120 km with the Midland autoGC at the center was created. Emission sources within 20km of the autoGC site were modelled discretely, while emission sources farther away were aggregated to centroid points in 4 km grid cells. Upstream emissions from oil and gas sources were modelled using the Methane Emissions Estimation Tool (MEET) aggregating emissions on an hourly basis. Midstream emissions were also estimated. Dispersion modeling was used to predict the hourly concentration of hydrocarbons at the autoGC site based on the site level modeled emissions and dispersion modeling from each of thousands of sites, based on regional meteorological data. Comparison of predicted dispersion modeling results with autoGC measurement shows that a large fraction of the nighttime measurement enhancement can be attributed to meteorological conditions and routine emissions. Large daytime concentration enhancement events are less related to routine emissions. This work demonstrates that regional ground-level monitor measurements combined with emission modeling techniques can be used to identify large emission events and their sources on a regional scale.

Human Health Considerations for the Use of Amine Solvents for Post-Combustion CO_2 Capture

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Carbon capture is an existing technology that is part of a strategy to combat climate change from CO_2 emissions. One common carbon capture technology is to use aqueous amine solvents to scrub CO_2 from post-combustion flue gas, but emissions from such systems may contain amine solvents, degradation products, and other impurities. Understanding the potential human health effects of these compounds is important before the technology is widely deployed. EPRI and other research over several decades on carbon capture has characterized waste streams in the field, conducted fundamental laboratory studies using selected amine solvents, including simulated atmospheric transformation to determine degradation products, and carried out toxicological studies. Most recently, EPRI investigated available human health, environmental, and physical hazard information as well as regulatory information for compounds identified in or expected to be in waste streams from the post-combustion CO_2 capture using amines. Building upon prior EPRI and United Kingdom (UK) Environment Agency research, 76 compounds from amine-based CO_2 capture processes were identified. Information on human health, environmental, and physical hazards was compiled from toxicity databases for these 76 compounds. Data collected included hazard classifications under the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), physicochemical properties, and a subset of regulatory determinations and exposure limits. Toxicity, mutagenicity, and endocrine activity data were summarized from prediction tools. Results were presented in the form of heat maps, allowing for enhanced visual evaluation of the detailed results. Overall, 13 compounds have information indicating that they have low potential for human health risk, while 33 compounds, which include amines, nitrosamines, metals, amides, and aldehydes, should be prioritized for human health risk evaluations based on information suggesting they are carcinogenic, mutagenic, or toxic for reproduction, or cause single target organ toxicity following repeated exposure. The compounds of interest are not currently highly regulated, with several having US drinking water standards, some Clean Water Act water quality criteria, some having air criteria pertaining to acute exposures associated with an industrial accident, and some having occupational exposure limits. The research findings indicate which compounds should be considered priorities for additional evaluation, including more detailed dose-response assessment.

Econometric model derived from meta-analysis to estimate VSL and VOLY associated to air pollution at a global level.

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Supporting policy decisions concerning the health impacts of air pollution requires trustworthy methods that balance the costs of risk reduction with the expected benefits, measured in terms of prevented premature deaths. These benefits can be quantified through the Value of a Statistical Life (VSL), representing individuals' willingness to pay for reduced mortality risk, and the Value of a Life Year (VOLY), which accounts for pollution's impact on life expectancy. However, obtaining reliable VSL and VOLY values is challenging, as methodologies vary widely across—and even within—countries, and many of them lack robust, country-specific data. This inconsistency affects the comparability between countries in global assessments. To address this gap, a database of 494 VSL estimates specific for the impact of air pollution was compiled from the literature, covering 186 countries across all continents. Using these estimates, a meta-analysis was conducted to integrate them into a specific econometric model assessing only the share of health costs attributable to air pollution worldwide. The model incorporates economic, socio-economic, demographic, and health proxies to tailor unit cost estimates according to each country's characteristics. According to our study, the VSL ranges between 17,715 PPP I$ (2019) and 10,273,480 PPP I$ (2019). VSL values are about 20 times higher than their corresponding VOLY values. This approach, new in air pollution analysis, enables a more specific application of VSL/VOLY in policy contexts at the country level and could be extended to the subnational level. This work aims to improve quantitative and comparable estimates of the economic benefits associated with air pollution abatement policies and the consequent reduction in premature deaths in international or global assessments.

HEI energy

Characterizing Synthetic Drilling Mud Emissions and Impacts for Regional Air Quality

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Background:

Advanced horizontal drilling and hydraulic fracturing techniques have driven a rapid expansion of unconventional oil and gas development (UOGD) across many U.S. states, raising concerns about potential air quality and human health impacts.

Drilling mud is an essential component of drilling operations. Recent studies have identified elevated emissions of C_8-C_{10} alkanes associated with synthetic drilling muds. These compounds exhibit greater reactivity with hydroxyl radicals (OH), increasing the potential for ozone formation. This study focuses on characterizing VOCs emitted from synthetic Neoflo-based drilling muds used at Denver-Julesburg Basin multi-well pads.

Methods:

VOC profiles were analyzed through headspace analysis of authentic drilling mud samples in the lab, weekly-integrated samples and plume-triggered air samples collected near drilling operations, and grab samples collected on-pad near drilling mud recycling equipment. A positive matrix factorization (PMF) source apportionment method is used to identify emission characteristics associated with drilling mud volatilization. The AMS/EPA Regulatory Model (AERMOD) with previous VOC emissions rates reported from outgassing from petroleum-based (Gibson) and synthetic (Neoflo) drilling muds is used to predict near-pad pollutant concentrations. The OH reactivity of emissions from the two drilling muds is compared to characterize potential impacts on ozone formation.

Results:

Fourteen VOCs were identified as major species outgassing from Neoflo-based drilling mud. PMF analyses identified 6 source factors for each site. Commonly observed factors included long-lived O&G, short-lived O&G, combustion and background sources.

Conclusions:

The fractional composition matrix of these 14 VOCs is similar to those seen in plume-triggered samples collected during drilling operations, revealing the “fingerprint” matrix could be a robust way to identify the influence of Neoflo-based drilling mud VOC outgassing in ambient air. Drilling mud outgassing was estimated to contribute about 18% to VOC concentrations and 30% to OH reactivity at near-pad locations.

Trends in Emissions and Exposure from Unconventional Oil and Gas Activity in the Marcellus-Utica Region, 2004-2023

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Background and Objectives

The Marcellus and Utica shale formations have significantly shaped the U.S. energy landscape, replacing coal as a dominant energy source. While emissions from fossil fuel combustion are well studied, air emissions during the drilling and completion stages remain less explored. Understanding these emissions is critical for assessing their impact on air quality and exposure risks. This study estimates emissions from shale development activities and models their dispersion to evaluate population exposure over two decades.

Methods and Approach

The entire study period (2004–2023) is divided into four distinct intervals to account for technological evolution over time. Emissions were estimated using publicly available datasets and EPA methodologies (AP-42), incorporating technological changes over these time periods. Drilling and completion times are analyzed, refined, and processed to represent the actual operational durations for these activities. Expert input was gathered to assess industry-wide shifts in equipment and operations. AERMOD was then used to model daily average pollutant concentrations at a 1 km resolution for NO_2, SO_2, $PM_{2.5}$, CH_4 and VOCs, integrating well site emissions, meteorological data, and topography. Ozone levels were estimated based on daily average NO_x and VOC concentrations. Population estimates from American Community Survey (ACS) were used for exposure risk and environmental justice analysis.

Results and Findings

NOx was identified as the primary pollutant from drilling and completion activities, with emissions peaking in 2010 due to high drilling activity and widespread diesel engine use. Although drilling peaked in 2014, emissions significantly declined primarily due to advancements in cleaner fuel use, equipment efficiency, and improved operational practices. Modeling results indicate that a small subset of high-activity sites, particularly near population centers, dominate exposure risks. VOC exposure, however, shows a continuous increasing trend as oil and gas production leading to increased fugitive VOC emissions.

Conclusions and Interpretation

Emissions trends closely follow drilling activity but are mitigated by technological improvements. While peak emissions occurred around 2010, cleaner practices have reduced per-well emissions despite continued gas production growth. However, unconventional oil and gas operations remain a significant source of air pollution, especially with VOCs, highlighting the need for continued monitoring and further emissions reductions.

HEI energy

Emission Characterization from Unconventional Oil and Gas Development in the Eagle Ford Shale

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Emissions from unconventional oil and gas development (UOGD) are increasingly relevant to human health and atmospheric chemistry following recent production growth in the Eagle Ford Shale (EFS). Individual UOGD sites exhibit diverse emissions from flaring and evaporative sources. This study aims to characterize site emissions by utilizing mobile measurements of gas-phase and particle-phase pollutants in the EFS region.

Mobile measurements were conducted in the spring and fall of 2023 using an electric vehicle to avoid self-sampling. Onboard instrumentation comprised a Vocus 2R Proton Transfer Reaction Time of Flight Mass Spectrometer (Vocus-PTR-LToF-MS) to measure volatile organic compounds (VOCs), a Picarro Cavity Ring-Down Spectroscopy (CRDS) formaldehyde and methane analyzer, a Magee Scientific Aethalometer AE33 to measure black carbon, and a LI-COR LI-850 CO_2 monitor. Methane destruction removal efficiency (DRE) was calculated for each source following the approach described in Caulton et al. (2014). Reported methane mole fractions from the region were taken from the EPA Facility Level Information on GreenHouse gases Tool (FLIGHT).

Calculated DREs spanned from 91.38% to 99.29% with a mean of 95.98% and a median of 96.99%, which is a similar range observed in an aircraft campaign by Lavoie et al. (2017) in the EFS. These data indicate that methane destruction is not always complete in this region. Flaring plume enhancement data were used to calculate emission factors (EFs) with respect to CO_2 (ppt/ppmCO_2). Marked diversity in EFs (e.g. due to incomplete combustion or mixed evaporative and flaring plumes) was observed in some locations. Influence from flaring and non-flaring sources at UOGD sites was confirmed using multivariate factor analysis.

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Disparity in ambient PM_(2.5) exposure and its attributable health burden across the population subgroups in India

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Background and Objectives

Exposure to ambient PM_(2.5) is the largest environmental risk for public health in India. While the Global Burden of Disease (GBD) Study has generated state-level disease burden estimates attributable to ambient PM_(2.5) in India, whether the burden varies across diverse demographic subgroups, and if yes, by how much, are unknown.

Methods

Here we first estimated the disparity in ambient PM_(2.5) exposure across subgroups in by integrating satellite-derived PM_(2.5) concentration with the individual-level demographic information from the National Family Health Surveys. We then used hierarchical logistic mixed effect model to estimate the association between the odds of three non-communicable diseases (NDCs) - diabetes, high blood pressure, and heart disease, with ambient PM_(2.5) exposure stratified by participantsâ€™ gender, wealth, and caste; adjusting for socio-demographic covariates. Lastly, following the GBD framework, we used our model-derived risk estimates to assess ambient PM2.5-attributable health burden across the demographic subgroups.

Results

We found the health burden attributable to ambient PM_(2.5) to be higher among the top and bottom quantiles of wealth-index, and other caste-subgroups than their demographic counterparts. The association between ambient PM_(2.5) and the NCDs varied across subgroups and was found to be higher among males than females and among other backward classes than other caste-subgroups. The ambient PM_(2.5)-diabetes association consistently increased from the poorest to the richest (ORs increased from 1.025 to 1.062), while the association with the other two NCDs was higher for the economically stronger subgroups. We estimated that males, other backward class, and deprived subgroups suffered from higher morbidities [2.02-11.79 million (1.86-13.92)] than their demographic counterparts, predominantly from diabetes and heart disease.

Conclusions

India should implement targeted air pollution mitigation strategies prioritizing the vulnerable subgroups, along with controlling other modifiable risk-factors, simultaneously, to achieve environmental and health equities in the foreseeable future.

Evaluating the Reliability of Personal Air Sensors for Air Pollution Epidemiological Studies

Drover, RW; Pinegar, L; Gallagher, A; Dennison, JB; Dell, L

Ramboll

Air pollution accountability studies evaluate changes in health effects from improvements in ambient air quality due to policy changes, interventions, or events. However, these studies can yield ambiguous results. Improved estimation of personal exposure to account for indoor as well as outdoor air quality may provide more reliable results. Recent recommendations emphasize improving exposure estimates through satellite technology, air sensors, and wearable devices. Personal air sensors for fine particulate matter (PM2.5) and ozone offer real-time, individualized exposure data, but concerns remain regarding their reliability when used under a range of real-world conditions and for extended periods of time.

We conducted a literature review, including peer-reviewed publications and authoritative grey literature, evaluating the quality and reliability of personal air sensors for PM2.5 and ozone, considering the testing duration. Performance metrics examined include sensor precision, detection limits, response times, and susceptibility to environmental factors. Usability factors like data collection, power requirements, ease of deployment, availability, cost, and long-term operational durability were considered, which are critical for field deployment in accountability research.

When synthesizing the available literature, we focused on which personal air sensors and characteristics are most suitable for use in epidemiological research and where gaps in sensor performance or availability exist. While many sensors perform adequately for basic air quality monitoring, significant challenges remain in their ability to meet the stringent requirements of accountability research, especially regarding long-term accuracy and reliability. We recommend enhanced sensor validation, improved performance metrics, and practical deployment solutions to better support credible, outcome-oriented epidemiological studies. Where current technologies or certifications fall short, we provide recommendations for sensor improvements, standardization, and formal validation criteria emphasizing the need for better real-world performance, durability, and data handling and evaluation options.

Respiratory exposure to inert particulate matter during pregnancy leads to oxidative stress and cardiac proteomic remodeling

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Titanium dioxide (TiO_2) is generally considered an “inert” particle and is used as a control in pollution studies; however, it is generating increasing concern due to its widespread presence in environmental and manufacturing industries. During pregnancy, increased cardiovascular stress occurs, aggravating prior conditions or inducing emergence of new conditions like high blood pressure, diabetes, and preeclampsia. A relation of particle exposure and cardiovascular disease has been observed, however its role during pregnancy requires further understanding. Thus, we investigated the effect of TiO_2 exposure on cardiac tissue in the presence and absence of pregnancy. *In vitro* studies using a cardiomyocyte cell line post 1-hour exposure to varying concentrations of TiO_2 were performed to determine necrotic cell death effects and oxidative stress detection. This process was repeated to validate the role of oxidative stress in myocyte death using extracellular and intracellular antioxidants. Proteomic analysis was used to assess cardiac proteome remodeling upon intranasal exposure to TiO_2 in the absence and presence of pregnancy in mice samples, with validation done by immunoblots. We found an increase in cytotoxicity as well as presence of reactive oxygen species when myocytes were challenged with TiO_2. Oxidative stress inhibition with antioxidants N-acetylcysteine and catalase showed cytotoxic protection only with the former. Proteomics data exhibited that pregnancy leads to a more pronounced proteome remodeling upon TiO_2 challenge when compared to untreated controls and non-pregnant mice. Validation of these observations showed differential expression of inflammation markers that are associated with TiO_2 exposure in the pregnant and non-pregnant mice. These findings demonstrate that even an inert particle such as TiO_2 can cause cardiac damage with characteristics similar to those in myocardial infarction and ischemia. Exposure during pregnancy can exacerbate some of these effects. Preventative measures should be taken to limit exposure and future studies could indicate long-term exposure impacts.

Improved Assessment and Characterization of Traffic-Related Particulate Emissions (IMPACT): Year 2 Update.

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Background. In 2022, we initiated a three-year project to develop and apply better methods for assessing exposure to non-tailpipe (NTP) particles.

Methods and Approach

Objective 1 (characterize temporal patterns): We applied Positive Matrix Factrorization to i) long-term (2017-23) daily filter and ii) higher time resolution (2h, 2020-23) chemical speciation data collected in Toronto and Vancouver.

Objective 2 (characterize spatial patterns): Through three field sampling campaigns we collected 941 $PM_{2.5}$ and PM_{10} mass, speciation, and NOx samples at 40 sites across Toronto in Fall 2023, Winter 2023-24, and Summer 2024. This was supplemented by simultaneous mobile sampling to evaluate road dust resuspension.

Objective 3 (improve NTP analysis methods): We used pyrolysis GC-MS to analyse new and used tire samples for rubber and additives, and compared this to field samples collected beside a highway.

Preliminary Results and Findings.

Objective 1: PMF of the higher time resolution data indicates that 36% of the $PM_{2.5}$ mass in Vancouver is traffic related (17% NTP and 19% TP) vs.10% in Toronto (6% NTP and 4% TP). PMF of the long-term data resolved tailpipe, brake wear and road dust factors with lower contributions to $PM_{2.5}$ in Toronto on weekends, and at a background vs. a roadside site.

Objective 2: Marker elements (Ba, Ca, Ti and Fe) show substantial spatial variation across sites with differing traffic levels that is consistent across seasons. Resuspended road dust is lower on busier roads while tailpipe related pollutants (UFP, BC) have the opposite pattern. Resuspended road dust is higher in winter.

Objective 3: The ratio of tire additives (6 PPD, TMQ) to rubber decreases with tire aging. Moreover, this tire-additive ratio is higher in field samples of PM_{10} than in new or old tire samples. Detection of tire wear particles is very challenging and evidence so far suggests that tire wear makes a small (<5%) contribution to airborne ambient $PM_{2.5}$ even next to a highway.

Conclusions and Intepretation: Analysis of the data collected is already yielding better approaches to characterize and understand the spatial patterns of NTP across cities.

Review of existing frameworks to evaluate health impacts from air toxics and criteria pollutants

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People breathe a complex mixture of air pollutants, yet traditional approaches to quantifying health risks typically treat hazardous air pollutants and criteria pollutants separately. This presentation will cover a literature review of existing federal, state, and local approaches to incorporating health risks from both air toxics and criteria pollutants into assessments of health risk. Methods reviewed include those that combine both types of pollutants on current standard frameworks (i.e., AQI or total cancer risk). Other approaches typically calculate health metrics in some way, for example calculating disability-adjusted life years or estimating total costs related to health outcomes. Results from this study are intended to support decision makers in understanding opportunities to consider health impacts from all air pollutants and support effects to address cumulative health risks from air pollutants. Conclusions will also outline challenges and opportunities with these approaches and potential gaps for further research.

Applications of Statistical Analysis Methods to Sparse Data at Low Fine Particulate Matter Concentrations

Tiffani Fordyce, Exponent

Abstract: Background and objectives

Fine particulate matter (PM2.5) has been demonstrated to adversely affect human health and mortality. However, considerable debate exists over estimation of the precise Concentration Response Function (CRF) describing the relationship between PM2.5 and all-cause mortality. Literature evaluating the CRF for mortality at low levels of PM2.5 demonstrates that many studies do not have enough (or sometimes any) data at concentration levels below 9 and/or 12 micrograms per cubic meter. To evaluate potential improvements to CRF modeling techniques when applied to sparse data at low exposures, Al-Kindi et al., (2019) was chosen as the basis for a replication analysis and method development.

Methods and approach

The analysis performed by Al-Kindi et al. (2019) was replicated and used as a foundation to evaluate the application of alternative modeling methods. Two approaches are taken to address the impact of sparsity: 1) reducing the sparsity of exposure datasets by spatial interpolation of PM2.5 at intermediate points and 2) employing alternative methods of estimation that may have better relative performance under sparse data conditions. Techniques used for exposure data modeling included Inverse Distance Weighting and Kriging (Gaussian Process Modeling); CRF modeling included Poisson GAM and Pohar Perme estimation of net survival.

Results and findings

Overall, the replication analysis showed agreement with Al-Kindi et al.â€™s (2019) estimated treatment effects but found a lower mortality hazard at lower levels of PM2.5 exposure.

Conclusions and interpretation

Our findings suggest that mortality is driven by higher levels of exposure. Compared to the replication of Al-Kindi et al. (2019), the additional modeling techniques utilized found a lower mortality hazard when PM2.5 is low, rising to match or exceed the published mortality hazard at higher PM2.5 levels. Care should be taken as to the shape and form of the CRF curve to appropriately reflect modeling needs.

HEI energy

Assessing source contributions to air quality in unconventional oil shale plays

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Background. The impacts of oil and gas production on air quality results from a multitude of activities: drilling, hydraulic fracturing, production, storage and leaks at well-pad sites, burning of waste gas (i.e., flaring), operation of compressors, and emissions from transportation equipment needed to bring supplies and water or remove oil, gas and waste. From these activities, air pollutant emissions of concern including nitrogen oxides (NO_x) and volatile organic compounds (VOCs) such as benzene, toluene, ethylbenzene, and xylenes (BTEX). Climate change contributing emissions of methane (CH_4) and carbon dioxide (CO_2) are also a concern.

Methods. At a monitoring station located at the northwestern edge of the Permian Basin (PB) in Loving, NM, time-resolved data on pollutants and meteorology were collected from May 1st, 2023, through May 31st, 2024. The site was near a transportation route and downwind of several UOGD point sources, including a gas flare within 100 m. Non-negative matrix factorization (NMF) was conducted on 10-minute averaged concentrations to identify 5 source profiles. We examined the NMF-derived sources by wind direction and conducted an extensive analysis of hydrocarbon ratios to better understand the source contributions.

Results. The 5 NMF-derived sources suggest one that is dominant in evaporative oil and gas emissions, two that are attributed to combustion/flaring, and two that are attributed to transportation (vehicle traffic and diesel trucks). The two flaring factors showed directional impacts from to the northeast where the most flaring in the region occurs, and the southwest where the nearby flare was located. The transportation diesel factor is expressed along the main trucking route to the E and ESE, US Route 285. We found that ethane exhibited plumes arising from winds coming over the Permian Basin. Ratios of i-pentane to n-pentane further demonstrated that dominance of oil and gas related emissions across the study area.

Conclusions. Our findings point to regional emissions as a driving factor of elevated levels of oil and gas related pollutants. The source contributions confirm the strong relationship between observed hydrocarbon concentrations and regional well density, and a significant impact of regional gas flaring on air quality.

HEI energy

Atmospheric Radioactivity in Loving, NM, and its Relationship to Oil and Natural Gas Development in the Permian Basin

Detlev Helmig, Katherine Potter, Dani Caputi, Lara Cushing, Ryan Daly, Lisa Darby, Meredith Franklin, Gabriel Greenberg, Jacques Hueber, Jill Johnson, Gunnar Schade, Susan Simoncic, Michel Stahli

Airborne radioactivity from fossil fuel extraction and processing is poorly characterized but has recently received increased attention as several studies have shown elevated radioactivity levels with proximity to oil and gas production wells (1) and a Colorado refinery (2). Radioactive decay of radon poses a well-recognized health risk, i.e. the EPA estimates ≈21,000 lung cancer deaths annually in the US due to radon inhalation. Here, we report year-long, high temporal resolution monitoring results of airborne alpha radioactivity from an air monitoring station that is in proximity to an abundance of oil and gas well sites in the Permian Basin. Airborne gas phase radioactivity, primarily resulting from radon gas, and alpha radiation associated with particulate matter were monitored continuously at 10-minute time resolution over a full annual cycle at Loving, approximately 17 km south of Carlsbad, NM, with two dedicated high sensitive Bertin Technologies monitors. Airborne, radon-related radioactivty was elevated at nighttime vs. daytime (3x), and during winter vs. summer (2x). Gas and particle radioactivity were highly variable but strongly correlated with each other, with total 10-min radioactivity exceeding 100 Bq/m3 (the World Health Organization' suggested action level) regularly, and 200 Bq/m3 on several occasions. Total radioactivity showed correlations with natural gas (methane, ethane) and flaring tracers (acetylene, benzene), suggesting flaring as a possible contributing source. Highest airborne radioactivity was observed in airflow from a narrow sector to the northwest of the site, which had previously been mapped as an area of geologically elevated ground radioactivity levels. This source sector was also the primary direction for transport of air containing elevated hydrogen sulfide levels, which points towards co-advection of these two emissions from a shared source, such as emissions from sour gas wells (i.e. natural gas that contains elevated (> 100 ppm) amounts of hydrogen sulfide).

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https://doi.org/10.1080/10962247.2024.2393194

Challenges in Recalibrating a Stochastic Population-Based Air Pollution Exposure Simulation Model for a New Study Domain

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Background and Objectives:

The U.S. Environmental Protection Agencyâ€™s Air Pollutants EXposure (APEX) model is used to quantify inter-individual variability in exposures. APEX has substantial data requirements; however, its capabilities are attractive for application to other study domains, including internationally. Hong Kong (HK) is an urban area challenged by air pollution. The objective of this work is to demonstrate the recalibration of APEX for HK.

Methods and approach:

APEX simulates individual activities using time-location data for a population sample. APEX estimates microenvironmental exposure concentrations based on ambient air pollutant concentrations, infiltration factors (F_ (inf)) and indoor-generated sources (C_ (ig)), or indoor-to-outdoor (I/O) ratios. Key APEX requirements include: (1) defining sectors; (2) sector-level population and commuting data; (3) 24-hour time-location data; (4) ambient air quality data for roadways and general areas; and (5) F_ (inf) and C_ (ig) for typically visited microenvironments quantified either from representative measurements or obtained from literature.

Results and findings:

Population data were obtained from the HK Census. Commuting data were imputed using a gravity model. Time-location data were obtained from a travel survey. Hourly average ambient air quality estimates were buffered for roadways and general areas. Typically visited microenvironments in HK include buildings such as homes, schools, and offices, and vehicles such as Mass Transit Railway (MTR) and private cars. F_ (inf) and C_ (ig) are quantified for buildings and MTR based on measurements by collaborators. I/O ratios were quantified for private cars based on literature.

Conclusions and interpretation:

APEX has been successfully recalibrated for application in HK. This case study demonstrates a situation for which locally-available data can be adapted for input to APEX, and for which APEX can be applied to a new study domain using such data, even though the model was not originally designed for this application. The model results enable identification of high-exposure subpopulations and exposure mitigation strategies.

Traffic-Related Air Pollution, Lipoproteins, and Cardiovascular Disease Risk in the VITamin D and OmegA-3 TriaL (VITAL)

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Background and objectives: Multiple pathways have linked air pollution with cardiovascular disease (CVD), the leading cause of death in the U.S. and globally. We are examining both cross-sectional and longitudinal associations of traffic related air pollution (TRAP) with incident CVD (including coronary heart disease [CHD] and stroke) events and exploring potential mediating lipid pathways of risk in the study population of the VITamin D and OmegA-3 TriaL (VITAL), a double-blind, placebo-controlled clinical trial of vitamin D and marine omega-3 fatty acid supplements in the primary prevention of cancer and CVD.

Methods and approach: We use satellite-based small-scale (≤1 km) exposure models to estimate daily residence-specific ambient nitrogen dioxide (NO_2), particulate matter <2.5 µm ($PM_{2.5}$), and 11 tailpipe and non-tailpipe source $PM_{2.5}$ components. Cox proportional hazards models, stratified by sex, age, and randomization year, are fitted to estimate associations of long-term exposure with CVD outcomes. Results are presented as hazard ratios (HR) per interquartile (IQR) increase in exposure, adjusted for BMI and smoking.

Results and findings: During follow-up (5 years of intervention plus 6 years post-intervention, ongoing), a total of 2,314 CVD events occurred (1,111 CHD and 523 strokes) among 25,747 study participants with residence in the contiguous U.S. (50.6 % women, 69.7 % White, 19.8 % Black, mean baseline age 67.1 yrs). Average annual exposure before randomization was 19.6 ppb NO_2 and 9.0 µg/m^3 $PM_{2.5}$.

NO_2 and total $PM_{2.5}$ mass were not associated with CVD or CHD. By contrast, $PM_{2.5}$ components calcium (Ca), potassium (K), and silicon (Si) were associated with increased risk of CHD (Ca: HR=1.08 [1.03-1.14]; K: HR=1.10 [1.03-1.17]; Si: HR=1.07 [1.02-1.14]). Associations with total CVD had a similar pattern but were weaker.

Conclusions and interpretations: Exposure to several markers for local non-tailpipe traffic was associated with increased long-term risk of CHD and CVD in the VITAL study population.

Logistics of zoning, zoning for logistics: Toward development for freight and community health

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Background and objectives

The expansion of warehousing and distribution centers (W&Ds) has raised concerns about adverse health effects from freight traffic. These impacts may disparately affect adjacent low-income households and populations of color. While local governments wield several regulatory tools to manage freight traffic and development, few may be as consequential to public health disparities as zoning. This study synthesizes U.S. zoning actions toward W&D development, and as a tool for protecting community health in areas historically burdened by freight traffic. Specifically, we:

- analyzed 92 zoning action cases at the municipality, county, and state levels;
- built a typology for discretionary and regulatory zoning actions, including long-term planning considerations;
- assessed the level at which community health featured in or informed these actions.

Methods and approach

Our qualitative approach sampled zoning amendments across 51 municipalities, 9 counties, and 7 states. We used structural coding to analyze 213 publicly available documents including policy and ordinance texts, council meeting transcripts, zoning codes, long-term plans, and developer and advocacy websites. We coded for descriptive mentions of traffic-related impact and disparity mitigation.

Results and findings

Despite recent regulatory attention toward W&D development at the state-level, most local actions were discretionary. While our study offers examples of zoning councils aligning with community groups—usually following litigation—discretionary processes have drawbacks. Other jurisdictions regulated W&Ds to restrict their expansion by revisiting land use definitions, development standards, and conditional use permits, albeit with little indication that these changes directly benefit communities historically burdened by freight traffic.

Conclusions and interpretations

We found that local jurisdictions lacked a unified regulatory approach and gave limited consideration for the disparate health impacts attributable to W&Ds. However, long-term planning and state environmental policies guided the local jurisdictions with the most health-explicit actions. Ensuring community health factors into freight-related land use decisions requires clear strategic priorities and environmental safe-guards for vulnerable populations.

Comparing the performance of dispersion models for estimating pollutant concentrations in oil and gas production regions

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Concentrations of hydrocarbons at a receptor site, due to emissions from unconventional oil and gas development (UOGD), were predicted using multiple dispersion models as part of the Tracking Community Exposures and Releases (TRACER) model, a framework for estimating exposures to emissions from UOGD.

Measurements of ambient ethane concentrations collected over an 81-day period at an air quality monitoring site in the Eagle Ford Shale (EFS) oil and gas production region are compared to predictions based on estimates of routine emissions and three dispersion models (CALPUFF, AERMOD, the Single Equation Gaussian formulation). Emissions and dispersion modeling were performed for each of 20,000+ oil and gas sites in the EFS. Emissions were estimated for sites in the upstream and midstream sectors using the Methane Emissions Estimation Tool (MEET) and throughput scaled emission factors respectively.

Daily time series of measured ethane concentrations consistently displayed maxima in the early morning hours (3-7 a.m. local time). The CALPUFF modeling suite reproduces this trend when coupled with routine emissions estimates, suggesting the diurnal pattern is primarily a result of meteorological variations rather than a non-routine nighttime emission source, although some evidence of non-routine emissions is present. Differences in the predictions from AERMOD and the Single Equation Gaussian formulation will likely arise due in part to the steady state assumption underlying both models and the different approaches each model uses for estimating the dispersion parameters among other factors.

More complex air quality models generally have the potential to produce more accurate results, but in regions with simple terrain and relatively homogenous meteorology they may not offer enough improvement to warrant the added computational expense. The selection of an application-appropriate model that weighs the benefits and limitations of various models should be considered in any air quality study.

HEI

Assessing the impact of non- tailpipe emissions from traffic on the asthmatic airway (IONA)

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Background and objectives Non-Tailpipe Emissions are currently unregulated, and their health impacts under explored. To date, no research has explored whether real-world non tailpipe emissions are causally related to worsening of asthma. This work evaluates the hypothesis that clinically important adverse acute asthmatic responses are driven by non-tailpipe components within coarse mode PM.

Methods and approach 44 adults with stable mild to moderate asthma were exposed using a static bicycle exercise protocol to three environments of contrasting non-tailpipe emissions in a randomised cross-over experimental design, comprising: an urban background site (Honor Oak Park); and two 'non-tailpipe' emission sites: stop-go traffic (Marylebone Road) and fast freeway traffic (White City). Lung function was quantified by spirometry, (FEV1 primary outcome) with immune responses assessed in nasal lavage (IL6 primary outcome). Air pollution was highly characterised including brake wear (BW) and tyre and road wear (TRW) at all three sites using positive matrix factorisation.

Results and findings Analyses by site revealed a differential pattern of lung function responses between exposures at White City and Marylebone Rd compared with the background site, with FEV_1 at the exposure mid-point reduced at White City: –0.16 (-0.27-0.06) L, p=0.002, but not Marylebone Road (p=0.25). We observed a significant increase in airway resistance in relation to $BW_{2.5}$ exposure immediately post exposure (coefficient 0.64; p=0.04). Increased nasal mucosal IL-6 responses were related to PM_{10}, and NO_2 concentrations during the exposure period across all three sites (p=0.017 and 0.007, respectively), but not $PM_{2.5}$ (p=0.12).

Conclusions and interpretation. It is possible to accurately quantify exposure to different sources of PM using high-time resolution chemical composition. Criterion pollutant, BW and TRW particulate exposures were associated with adverse acute impacts on lung function and immune responses in exercising adults with mild to moderate asthma.

Emerging evidence for the impact of Electric Vehicle sales on childhood asthma: Can ZEV mandates help?

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Growing epidemiological studies indicate a significant fraction of asthma cases can be attributed to traffic-related air pollution (TRAP). Zero emission vehicle (ZEV) mandates—one of the most forward-looking climate policies in the United States—aim to reduce TRAP by mandating automakers to sell a certain fraction of Electric Vehicles (EVs) annually; however, their public health benefits are largely unknown. We conduct the screening step of the health impact assessment (HIA) of real-world EV sales to estimate the impact of ZEV mandates in reducing childhood asthma. Using publicly available US state and national datasets, we isolate the burden of childhood asthma attributable to TRAP from 2013 to 2019 and examine the influence of EV and non-EV vehicle sales and fleets on asthma incidence and prevalence using a generalized linear mixed model. Our analyses indicate that new EV sales have reduced asthma, with one asthma case prevented for every 264 (95% CI: 113-401) new EVs on the road. The rise of new childhood asthma cases from new car sales can be prevented when non-EV sales are replaced with EV sales at an annual market share of 21.4% (7.1-41.6%). Extending our analysis to the entire vehicle fleet, we project that when EVs reach 53.0% (35.5%-76.9%), childhood asthma due to tailpipe emissions can be eradicated completely. Screening results conclude that ZEV mandates implemented over the past decade are already exhibiting measurable public health benefits, suggesting that a broader adoption could significantly reduce the asthma burden, thus we recommend a full HIA for ZEV mandates to fully assess their potential.

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During 2023-2024, southeast New Mexico was the second most polluted ozone region in the U.S. largely due to oil and gas emissions

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Atmospheric ozone pollution has been declining in most rural and urban areas in the US due to the reductions in emissions of nitrogen oxides (NOx) and volatile organic compounds. While ozone remains elevated in some metropolitan areas in CA, TX, CO, and the northeastern US, ozone Design Values (the 3-year mean of the annual 4th highest 8-h ozone average) are trending downward. A notable exception is Eddy County in rural southeast NM, where ozone has been increasing and has exceeded both the 2008 and 2015 National Ambient Air Quality Standard (NAAQS) since 2019. This area is mostly downwind of the Permian-Delaware oil and gas basin that stretches from northwest TX into southeast NM. Recent regulatory-grade air monitoring near Loving, NM, ≈17 km south of Carlsbad, shows regular 1-h ozone recordings above 70 ppb, with maximum values exceeding 100 ppb, especially on days with light southeast winds that are common during May-September. In 2023, 17 and 31 ozone exceedance days were recorded for the 75 and 70 ppb NAAQS, respectively, with a 4th-highest 8-h ozone value of 82.1 ppb. Even higher ozone values were recorded in 2024, with 21 and 46 exceedance days, with a 4th-highest 8-h ozone value of 91.5 ppb. The mean of the two-year 4th highest ozone is 86.8 ppb. In comparison, there are only four other counties, all in Southern CA, with similar or higher ozone Design Values, making southeast NM the second most ozone polluted region in the nation. Despite this abundance of high ozone days and serious NAAQS exceedances, the region has not yet been classified as being in non-attainment and thus ozone precursor emission reduction measures and associated air quality improvements are unlikely to be achieved anytime soon.

HEI energy

Air Quality Trends of Oil and Natural Gas Emissions in the Northern Colorado Front Range

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Background and objectives.

The Colorado Denver Julesburg Basin is the 5th most productive US oil and natural gas (O&G) producing region. Most of the recent O&G production growth has been in Weld County, north of Denver, where oil production doubled between 2014 and 2019. Well drilling has increasingly moved near and into populated areas of the Northern Colorado Front Range (NCFR), triggering concerns and opposition from citizens and local governments. A series of regulations have been implemented by the State of Colorado to reduce the industry's emissions and impacts, and ease community concerns. This study investigates atmospheric records of primary O&G pollutant emissions for changes over time, and resulting air quality trends.

Methods and approach. Methane, nonmethane hydrocarbons, and nitrogen oxides were investigated. Several different air monitoring records were considered, including continuous surface data from locally funded programs, canister samples collected by the Colorado Department of Public Health and Environment, and tropospheric ethane column data from the National Center of Atmospheric Research. Data were filtered by air mass origin using wind direction and back trajectories to increase selectivity to O&G sources. Lastly, data were subjected to a NOAA trend analysis tool that delineates seasonal, annual, and multi-year concentrations changes.

Results and Findings. All methane data showed increasing mole fractions, albeit at a lower rate than in the background atmosphere. O&G-associated hydrocarbons, i.e. ethane and propane, generally showed decreasing atmospheric mole fractions across monitoring sites and data products, although the rates of decline varied between sites. Similarly, benzene levels have been dropping.

Conclusions and interpretation. Methane and petroleum hydrocarbon emissions from O&G industry activities appear to be trending downwards in the NCFR. New well development and O&G production have leveled off during recent years, although not declined. Consequently, declining atmospheric emissions are likely the result of a gradual improvement in emissions intensity (i.e. emissions per unit of produced O&G).

HEI energy

UOGD operations in Texas: population exposure assessment and implications for future health studies

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Background and Objectives

Unconventional oil and gas development (UOGD) in the Eagle Ford Shale (EFS) is a major source of VOC emissions, contributing to air pollution, climate change, and public health risks. The rapid growth of UOGD in the U.S. has increased emissions of methane, ethane, propane, and other VOCs, exacerbating environmental and health concerns. We aim to quantify UOGD processes contributions to air pollution exposure in Karnes County, Texas.

Methods and approach

Motivated by reduced complexity models used in health studies, we compare multiple exposure assessment tools, including Inverse Distance Weighting (IDW), Inverse Distance Weighting with wind speed and direction (IDWmet), Gaussian Model, and AERMOD. We use the models to estimate pollutant concentrations on a high-resolution grid (1.33×1.33 km^2) covering Karnes County, TX.

Results and findings

Meteorological variations have a greater impact on temporal pollutant concentration fluctuations than emissions variability. Among emission sources, tank flash contributes the most (44%) to pollutant concentrations. Sources within a 15 km radius account for most (85%) of pollutant concentrations, compared to sources beyond 15 km. Spatially, pollutant concentrations form a southwest-to-northeast band, with lower concentrations in the Southeast. This spatial pattern is driven by the combination of emission source density and prevailing wind direction. Modeled daily concentrations of all pollutants exhibit an average correlation (R) of 0.90 for IDWmet, 0.7 for AERMOD, and 0.5 for Gaussian with observations. Average nighttime pollutant concentrations are higher than daytime levels, primarily due to wind speed.

Conclusions and interpretation

Population-weighted exposure estimates indicate pronounced disparities across racial, ethnic, and income groups. Hispanic and White populations experience the highest exposure levels, while Native American and Asian communities face comparatively lower concentrations, largely due to geographic distribution relative to emission sources. Income-based analyses show that both lower- and higher-income groups experience greater exposure than middle-income groups.

RB

Air pollution source impacts at fine scales for long-term regulatory accountability and environmental justice

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Background and objectives. Researchers have identified differing health impacts and inequalities associated with source-specific fine particulate matter ($PM_{2.5}$). Our objectives are to: 1) create high resolution daily $PM_{2.5}$ source impacts from major source categories from 2011-2020 and 2) use the $PM_{2.5}$ source impacts fields to quantify source-specific exposure differences among population groups.

Methods and approach. We applied dispersion-normalized positive matrix factorization (DN-PMF) at over 300 monitoring locations across the contiguous United States. We identified five $PM_{2.5}$ source categories across most monitors: traffic tailpipe, secondary sulfate, secondary nitrate, biomass burning, and soil/dust. Next, we used the Community Multiscale Air Quality Model with the Integrated Source Apportionment Method (CMAQ-ISAM) to quantify source impacts on a 12 x 12 km^2 grid. We developed machine learning models to predict each $PM_{2.5}$ sources' daily concentrations from DN-PMF. The models included multiple spatial-temporal predictors, including CMAQ-ISAM $PM_{2.5}$ source impacts, meteorology, and land use. We then applied the machine learning models to predict $PM_{2.5}$ source impacts from each of the five sources at a fine spatial resolution on each day from 2011-2020 in the contiguous United States.

Results. We found changes in the dominant regional sources: secondary sulfate and nitrate $PM_{2.5}$ decreased on average while biomass burning $PM_{2.5}$ increased. Local sources such as industrial sources and automobile tailpipe emissions show an increase in some locations. Machine learning models performed well, predicting DN-PMF $PM_{2.5}$ source impacts with mean bias of ±0.05 μg m^{-3} and R^2 greater than 0.90 on average across spatial cross-validation holdout analyses for all sources.

Conclusions. Fine scale $PM_{2.5}$ source impacts reveal divergent trends in regional and local air pollution sources and opportunities for interventions to address elevated exposure and inequalities.

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Abstract Title: Characteristics of Medicare Decedents with Low-level Annual PM2.5 Exposure

Much recent PM2.5 research has focused on characterizing risk at the lower end of the concentration-response function. Notably, as average ambient PM2.5 concentrations have continued to fall across the U.S., significant associations between annual average PM2.5 and mortality are still found at concentrations well below the current PM NAAQS, with no identified threshold for the effect. Concentration response functions reflect relative risk adjusted for covariates that might otherwise bias estimates. However, controlling for these covariates precludes an understanding of the segment of the population who appear to be highly sensitive to ambient PM2.5, even at historically low concentrations.

The objective of this study is to examine demographic and health factors that may give rise to the apparent enhanced susceptibility of decedents with low average PM2.5 exposure in the year prior to death, using Medicare beneficiary, Chronic Conditions and National Death Index files, and pollutant files from NASA's Socioeconomic Data and Applications Center (SEDAC). We will describe long- and short-term PM2.5 exposure of Medicare fee-for-service beneficiaries enrolled between 2015 and 2016, along the entire gradient of exposure. Further, we will examine person and place characteristics of decedents across deciles of PM2.5 exposure, and of decedents and non-decedents within exposure deciles. This analysis will seek to determine whether a demographic and/or health profile of Medicare beneficiaries who appear to have particular sensitivity to ambient PM2.5 concentrations can be described.

HEI

Efficacy of Vehicle Emission Control Interventions in Ameliorating Air Pollution Exposure and Health Burdens in Marginalized Communities

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Background and Objectives

Air pollutants and greenhouse gases from the U.S. transportation sector are substantial drivers of negative public health outcomes and climate impacts – burdens that have historically been unjustly borne by marginalized populations. Through successful clean air regulations, transport-related pollution has declined, but disparities in exposure and health impacts persist, increasing the need for targeted policy interventions. However, assessing the efficacy of policies designed to reduce inequitable air quality and health burdens is challenging without highly spatially resolved and accurate characterizations of population exposures and susceptibilities.

Methods and Approach

To advance air quality characterization and regulation assessment, this project leverages multiple state-of-the-science tools, including satellite observations, a high-resolution statistics-based Land-Use Regression Model (LURM), vehicle telemetry data, and a high-resolution regulatory-grade chemical transport model (CTM). We use these tools to improve an inventory-based emissions dataset, better constrain air pollutant exposure, identify overburdened communities, and assess the recent finding that inventory-based emissions datasets underestimate heavy-duty vehicle pollutant emissions in warehouse-prevalent environments.

Results and Findings

The majority of our research is focused on North America's largest freight hub, Chicago, IL, where 1 in 7 vehicles on urban interstates are trucks. On-going work is assessing the air quality (nitrogen dioxide, fine particulate matter, and ozone), health, and distribution of benefits and tradeoffs that result from implementation of three regulatory mechanisms: the EPA Clean Trucks Rule, the Advanced Clean Truck Rule, and the Heavy-Duty Engine and Vehicle Omnibus Regulations. Our initial findings indicate that these regulatory mechanisms provide broad benefits to society, in the form of pollutant and greenhouse gas reductions, with notable health benefits for marginalized populations.

Conclusions and Interpretation

Ultimately, the work described here will advance our air pollution exposure characterization capabilities and provide rigorous assessments of the efficacy of transport-related emission reduction policies in ameliorating harmful exposure and health outcomes.

Small Data, Big Impacts: Scaling Local Research to Inform Electrification Policies

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3. WE ACT for Environmental Justice

4. RMI

Community-level monitoring has been instrumental in highlighting local outdoor air pollution challenges, yet indoor air, where we spend 90% of our time, has not received the same attention. Gas appliances, specifically, contribute significantly to poor indoor air quality, impacting respiratory health and disproportionately affecting vulnerable communities. While national studies highlight these risks, policymakers often are more influenced by local data most relevant to their respective constituents. Small, community-based studies provide this evidence, but their resource-intensive nature makes broad replication challenging.

Given the current federal policy environment, there will likely be increasing dependence on local action, and a corresponding need for scalable approaches to community-led air quality monitoring. A set of customizable toolkits and training resources, leveraging low-cost sensors, and fostering partnerships between researchers, advocates, and policymakers can help amplify the impact of small studies and provide the localized feedback necessary to drive electrification policies.

Here, we present how results from smaller studies, such as the WE ACT Out of Gas, In with Justice program, effectively translated into local policy changes by providing compelling, place-specific data on a gas-to-induction stove swap-out program in public housing. This study strengthened advocacy for electrification, demonstrating how localized research can drive meaningful policy shifts. We explore strategies for scaling similar efforts, including “plug-and-play” study designs, community engagement models, instrumentation libraries, and data-sharing frameworks that can support electrification programs at a broader scale. By developing sustainable, scalable approaches to community-driven research, “small data” can be a powerful driver for big changes in local policy.

HEI energy

Air Quality and Community Exposure Disparities in the Marcellus Shale Region: Spatial and Temporal Analysis

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Background and objectives

The oil and gas industry is a major U.S. economic sector, yet balancing its economic benefits with its environmental impacts is crucial, especially for local air quality. To date, the spatial and temporal patterns of air pollutants remain poorly understood in areas with extensive unconventional oil and gas development (UOGD). These pollutants often disproportionately affect socioeconomically more vulnerable sub-populations.

Methods and approach

This study examines the impacts of UOGD emissions on air quality trends and community exposures using a chemical transport model to assess emissions from both the oil and gas industry and other sources across the Marcellus Shale region. We first calculate $PM_{2.5}$ and Ozone exposure at the Zip Code Tabulation Areas level. We then investigate the relationship between demographic/socioeconomic variables and $PM_{2.5}$/ozone to assess community disparities. Third, we utilize air-pollution-specific vulnerability index to identify vulnerable and/or disproportionately impacted communities.

Results and findings

Our analysis shows that ozone follows a relatively stable pattern, with slightly higher concentrations in the summer and lower concentrations in the winter. In contrast, $PM_{2.5}$ concentrations fluctuate significantly, potentially influenced by events such as wildfires. Higher $PM_{2.5}$ concentrations are observed in the eastern region of Virginia and the central part of Pennsylvania, while higher ozone concentrations are detected in the western and southern regions of Virginia and the eastern and western regions of Pennsylvania. We find that counties with a higher percentage of White residents tend to have lower $PM_{2.5}$ concentrations, while counties with more Black residents tend to have higher concentrations. The vulnerability index also indicates that the southern part of the Marcellus Shale region is more vulnerable than other areas.

Conclusions and interpretation

These findings would provide evidence on how UOGD emissions impact local air quality and disproportionately affect vulnerable populations, ultimately informing policy and intervention strategies to mitigate these environmental health risks.

Description, Development and Application of the Integrated Transport and Health Impact Modelling Tool for Global Cities (ITHIM-Global)

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The Integrated Transport and Health Impact Modelling Tool for Global Cities (ITHIM-Global) is an open-source tool designed to assess the health and environmental impacts of transport mode shifts in low- and middle-income countries (LMICs). The model evaluates changes in all-cause and cause-specific mortality and years of life lost (YLLs) through a multi-pathway framework, including physical activity, air pollution exposure, and road traffic fatalities. It also estimates changes in carbon dioxide emissions resulting from these shifts.

ITHIM-Global employs a quasi-microsimulation approach to assign individualized exposure estimates by age, sex, and activity levels, using up-to-date exposure and dose-response functions that account for the non-linear relationship between physical activity and health. The model uses travel survey data to assign exposures for each participant.

To demonstrate its functionality and aid users, the model was applied to BogotÃ¡, Colombia, using three hypothetical scenarios that shifted 5% of trips to bus, car, or cycling. Results showed that increasing public or active transport improves public health, primarily through gains in physical activity and reductions in emissions in the bus scenario. However, cycling scenarios indicated increased deaths and YLLs due to heightened personal air pollution exposure. Shifting trips to cars worsened health outcomes due to decreased physical activity and increased pollution exposure.

ITHIM-Global serves as a flexible Health Impact Assessment tool adaptable to urban LMIC contexts. Its modular structure, individual and population-level analyses, and comprehensive documentation support city planners in developing healthy, environmentally-conscious transport policies. This poster will explore underlying assumptions and their influence on generalizable lessons for risk assessment and model development. Currently, the model is being applied to over 30 LMIC cities.

The Role of Physicochemical Properties of Combustion-Derived Particulate Matter in Health Effects

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This study examines the health impacts of PM2.5 emissions from wood, coal, and bunker fuel combustion by assessing hydroxyl radical (Â·OH) generation and cytotoxicity in bronchial epithelial cells, in relation to their physicochemical properties. PM2.5 samples were collected under various fuel types, combustion temperatures, and operating conditions.

Wood and coal combustion showed higher oxidative potential through Â·OH radical generation, while bunker fuel emissions had the strongest cytotoxic effects, driven by toxic organic pollutants affecting cell viability and membrane integrity. Low-temperature wood and coal combustion led to increased Â·OH generation due to higher levels of redox-active metals and brown carbon (BrC). In contrast, high-temperature combustion produced fewer Â·OH radicals due to reduced metal concentrations, despite elevated polycyclic aromatic hydrocarbons (PAHs), highlighting the dominant role of metals in radical formation.

Bunker fuel emissions, especially under running conditions, exhibited the highest cytotoxicity, primarily due to toxic organics like n-alkanes. These findings emphasize the varying health risks of combustion-derived PM based on fuel type and combustion conditions, underscoring the need for tailored mitigation strategies to reduce harmful exposures. A comprehensive evaluation integrating cell exposure assays and Â·OH radical detection enhances understanding of combustion-related health effects.

Predicting cardiometabolic health and air pollution in future transportation landscapes using agent-based models (TRANSCAPE)

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Background and objectives

Ambient air pollution is among the top five risk factors for the global disease burden, with compelling evidence linking fine particulate matter ($PM_{2.5}$) to various health issues.. Particles from mobile sources (traffic-related air pollution, TRAP) are strongly linked to cardiometabolic disease exacerbation, likely due to their small size (mostly in the ultrafine range below 100 nm) and chemical composition (e.g., trace metal, black carbon). However, our understanding of the effects of non-tailpipe emissions (brake and tire wear) is still inconclusive. Additionally, the impacts of future changes in the transportation landscape on cardiometabolic health are understudied.

Methods and approach

We develop an advanced exposure model from a combination of comprehensive urban-scale air quality modeling using the Parallelized Large-Eddy Simulation Model (PALM) with a representation of human activity using the Multi-Agent Transport Simulation (MATsim) agent-based model. This exposure model is linked to strong epidemiological evidence, allowing us to use an existing population cohort (Cooperative Health Research in the Region of Augsburg, KORA) to estimate individual health effects, focusing on clinical and subclinical markers of cardiometabolic disease. Personal Exposure Monitors (PEMs) are used, amongst other sources, for model evaluation.

Results and findings

We detail a mobility questionnaire recently administered to the KORA cohort participants. The use and calibration of PEMs is outlined. Additionally, we present the setup and configuration of the PALM model for Augsburg and its surroundings. The methods to link traffic emissions from agent-based estimates with air quality modeling are presented. Furthermore, we discuss how we link agent-based model results with evidence from the KORA cohort.

Conclusions and interpretation

Research within the TRANSCAPE project has started, and first results are presented here. Gathering ground truth from the KORA cohort is ongoing. Model setups are converging, and integration has begun.

Impacts of Unconventional Oil and Gas Development on Concentrations and Composition of Volatile Organic Compounds and Particulate Matter in the Eagle Ford Shale

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Unconventional oil and gas development (UOGD) in the United States continues to grow thanks to technologies such as hydraulic fracturing and horizontal drilling. However, the effects of UOGD on air quality, climate, and human health are poorly characterized.

We measured gas-phase and particle-phase pollutants in the spring and fall of 2023 in Karnes City, a rural town located within a large oil and gas production region in south-central Texas called the Eagle Ford Shale. The measurement site was collocated with a Texas Commission on Environmental Quality measurement facility. Gas-phase volatile organic compound (VOC) emissions were measured using a Vocus high resolution proton transfer reaction time-of-flight mass spectrometer (Vocus), an iodide high resolution time-of-flight chemical ionization mass spectrometer (CIMS), and an automated gas chromatograph (GC). Particulate matter was measured using an Aerosol Chemical Speciation Monitor (ACSM) and Scanning Electrical Mobility Spectrometer (SEMS).

We observed intermittent, elevated concentrations of light alkanes and aromatic hydrocarbons, often at night. These plumes could be a result of routine emissions and favorable meteorological conditions, or non-routine emission events. In the Vocus data, we see some larger molecules (>C10) that are often not detected by traditional GC analysis. In the CIMS data, we see chlorine which is a highly reactive oxidant. Chlorine and other oxidants react with VOCs to form secondary pollutants including ozone and secondary organic aerosol. At the site, VOC plumes were followed by organic aerosol plumes. Mass spectral analysis shows that much of the organic aerosol was oxygenated, consistent with its formation from VOC oxidation. Particulate matter concentrations were lower in the fall than in the spring.

Overall, we found that UOGD emissions influence air quality in Karnes City. These measurements are contributing to the development of a model that can be used to predict community exposures to air pollutants from UOGD.

Inverting Environmental Policy: A Bayesian Framework for Achieving Triple Wins in Air Quality, Climate, and Equity

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Background and Objectives: Traditional environmental policies are generally designed in a forward simulation approach: formulating an idea, estimating emission-changes, and modeling the resulting changes to air pollution, climate mitigation, and environmental disparity. This process is computationally inefficient for testing multiple strategies and poorly-suited for optimizing with multiple objectives. Here, we invert this pipeline and start from the desired outcome; we then derive emission-reduction pathways that achieve a â€œtriple winâ€� in exposure, climate, and equity across the contiguous United States using a novel receptor-oriented, Bayesian optimization method.

Methods and Approach: Our approach draws from atmospheric inverse modeling, setting an idealized concentration surface â€” meeting the particulate matter (PM_(2.5)) standard everywhere â€" as the target variable. We derive spatially explicit emission-reductions that represent an optimal way to meet that target. We apply this approach to four broad policy goals: Air Quality Only, Climate Priority, Equity Priority, and Triple Win. We apply this framework using the 2017 National Emissions Inventory, InMAP Source-Receptor Matrix, demographic data, and CO_(2) emissions.

Results and Findings: While all scenarios meet the PM_(2.5) standard, they differ in which emissions are reduced (i.e., which chemical species and in which locations). Preliminary results suggest that the quantity of emission-reduction is relatively similar among scenarios investigated; the differences that arise are more focused on location, chemical species, and sector. This framework could have strong implications for how we think about the challenge of how environmental policy can attain the triple-win.

Conclusions and Interpretation: Here, we demonstrate a novel technique for identifying optimal, pollutant-specific locations for emission reductions. We apply this method to consider possible options for how the United States could achieve its air pollution, climate, and equity goals, individually and together. Our approach provides a data-driven and scalable strategy for simultaneously achieving a triple win.

JW

Pollutant Exposure Following Fires at the Wildland Urban Interface: Insights from the Eaton and Palisades Fires

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Devastating fires in Los Angeles County, CA occurred in January 2025 at the wildland-urban interface (WUI), consuming vegetation, residences, and commercial properties. The resulting emissions were different than wildfire emissions that primarily consume vegetation. Human exposures occurred directly from the fire in the short-term for first responders and displaced residents, and will continue in the long-term for those who will rebuild or continue to live in the area. This work seeks to add to the current understanding of fires at the WUI by describing the initial results of a multi-institution field campaign in the weeks that followed the fires.

Volatile organic compounds and particulate matter composition measurements were made in and near the burned areas by a Vocus proton-transfer-reaction time-of-flight mass spectrometer (PTR-TOF-MS), a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS), an aethalometer, and a Toxic-Metal Aerosol Real-Time Analysis (TARTA) instrument in February 2025. These mobile measurement efforts were conducted in the Pacific Palisades and Altadena areas during various times of day and weather conditions, enabling mapping of outdoor pollutants and stationary indoor-outdoor measurements in several single-family residences in these areas.

Pollutants typically associated with wildfires were detected, along with multiple pollutants, including halogenated organics and metals, that are characteristic of WUI fires. Initial results of this campaign show increased concentrations of gas and particle-phase pollutants in the aftermath of the fires in the Altadena area, relative to surrounding areas. Concentrations in the Pacific Palisades were lower than in Altadena, in part due to post-fire meteorological conditions. Multiple â€œhotspotsâ€ were identified, featuring enhanced concentrations of particulate matter and VOCs. Concentrations of VOCs were elevated in indoor environments, relative to the immediate outdoor environments of the structures. Results from this study have implications on human exposure to these pollutants in the weeks after a wildfire, and the response to future WUI fires.

BREATHE: Bridging REalms for Assessment of Traffic-related Health Effects

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Abstract:

Exposure to traffic-related air pollution (TrAP) poses risks to human health. Despite recent advancements in infrastructure and technology, the magnitude of consequent health benefits remains unclear, partly because current models lack the sufficient resolution to capture the complex dynamics and evolution of transportation systems.

We developed BEAM CORE[1], an agent-based transportation framework that simulates detailed activities for passengers and freight. This model integrates transportation, land use, demographics, and vehicle ownership at multiple spatiotemporal scales. By validating key emission modeling parameters like link-specific VMT and speed patterns in the San Francisco Bay Area, we demonstrate its adaptability for integration with InMAP[2] and AERMOD[3] to evaluate health implications of changes in transportation systems considering future vehicle technology and emerging travel trends.

BEAM CORE 2018 baseline has been calibrated, evaluated[1] and integrated with EMFAC2021[4] and fleet inputs from US-VIUS 2021[5] and TITAN's techno-economic analysis[6]. Compared to 2018, emissions from MHD exhaust and break/tire wear drop by 87%, 75%, and 56% for NO_x, $PM_{2.5}$, and PM_{10}, respectively, by 2050, assuming that 30% of trucks are battery-powered, 15% are hydrogen fuel cell-powered, and the remainder are diesel with nearly universal adoption of particle filters and NOx reduction catalysts. Additionally, initial results from integration of InMAP's ISRM[2] indicate that emerging travel trends led to notable health benefits through improved air quality overall, especially in urban centers and Silicon Valley areas, due to reduced $PM_{2.5}$ concentrations.

The agent-based transportation model BEAM CORE improves the specificity in estimating TrAP impacts. Future work will integrate InMAP[2], AERMOD[3] and exposure-response relationships from the HEI Traffic Review[7]. Applying this first-of-its-kind integrated pipeline to the Bay Area population will enable us to explore pathways between transportation system changes and health impacts. As an open-source solution built primarily on open data, BEAM CORE can be adapted for any region using local data.

A Resource Database of Cumulative Impacts Permitting Policies: Emerging Opportunities to Protect Environmental Justice Communities from Additional Burden

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The Environmental Justice (EJ) movement has called attention to the failure of government policies to address cumulative impacts (CI), the multiple and compounding social and environmental stressors that disproportionately affect low-income communities and communities of color. In recent years, driven by the organizing of EJ groups, there has been a proliferation, not only of CI mapping tools, but also of policy proposals to address CI in permitting, particularly at the state level. For the purpose of informing these efforts, we developed a database of state policies that codify a CI requirement in permitting decisions. Through web searches, consultation of existing databases, and direct knowledge, we collected state policies up through September 2024. Data were summarized on their purpose, scope of application, community definitions, and methodologies. The database includes information from eight states that have codified CI considerations in permitting decisions, and eleven states with bills that have not passed. Our analysis reveals the design choices that arise in CI lawmaking and rulemaking, which may influence the efficacy of protections. A critical decision point is the strength of the legal mandate to deny permits, but we also documented multiple ways in which even a strong mandate can be diluted. We found many policy features offering opportunities to cater to local context, even while existing policies can serve as models. Moreover, we observed rulemaking to be a critical and not merely â€œtechnicalâ€ counterpart of legislation, needed not just for making implementation possible, but also for knowing the ultimate strength of the policy.

Spatial-temporal patterns of elemental composition and sources of ambient fine particulate matter pollution in Accra, Ghana

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Background and objectives: Urbanization and economic growth in Sub-Saharan Africa (SSA) are influencing air pollutant concentrations, mixtures, and source contributions, with potential health implications. While measurement data in the region remains sparse, existing studies demonstrate that $PM_{2.5}$ concentrations exceed WHO guidelines by 2-12 times, are plateauing at levels lower than those observed in Asian megacities, and exhibit spatial variations driven by land-use factors. Still, little is known regarding the elemental composition of $PM_{2.5}$ and its relative source contributions at the city scale, which is crucial for targeted policy actions that protect public health.

Methods and approach: Between April 2019 and June 2020, over 600 weekly gravimetric $PM_{2.5}$ samples were collected from 146 sites across Accra, Ghana – a rapidly developing city in SSA. These sites covered a range of land-use and source influences representative of the region. Filters were analyzed for the presence of 45 elements using energy dispersive x-ray fluorescence. Positive matrix factorization (PMF) was applied to identify and quantify major sources.

Results and findings: Concentrations of elements associated with biomass burning (K, Br, Pb) and vehicle emissions (Ti, Fe, Cu, Zn) were highest in high-density residential and heavily trafficked neighborhoods, respectively. Additionally, we observed strong seasonal variations among some key crustal elements (Al, Si, Ca) and several elements associated with traffic emissions and biomass burning. Non-harmattan PMF models identified 4-6 major sources across sites including biomass burning (11-32%), traffic emissions and road dust (9-36%), solid and electronic waste combustion (0-35%), construction dust (0-30%), crustal dust (11-47%), and sea salt (8-67%). During the Harmattan season, crustal dust compried 52-68% of the total $PM_{2.5}$ mass.

Conclusions and interpretation: Although ambient $PM_{2.5}$ concentrations in Accra may have plateaued, levels remain elevated and vary widely. Developing effective and equitable public health policies to drive further reductions requires knowledge of $PM_{2.5}$ constituents and sources. This study fills this gap and will support health impact assessments of specific $PM_{2.5}$ constituents and their sources in a major SSA city.

Long-Term Trends and Air Quality Impacts of Oil and Gas Industry-Emitted VOCs in the Marcellus Shale Region

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The oil and gas industry is a major economic sector in the United States. Balancing economic sustainability with environmental impacts is a critical challenge, as oil and gas extraction activities have far-reaching effects on local and regional air quality. Oil and gas extraction releases hazardous air pollutants (HAPs), including volatile organic compounds (VOCs), and criteria air pollutants (CAPs) such as nitrogen oxides, and fine particulate matter.

This study aims to investigate the long-term trends of VOC emissions from oil and gas extraction and their impact on local air quality, with a focus on the Marcellus Shale region in West Virginia, Ohio, and Pennsylvania. Specifically, we analyze the trends of six key HAPs: benzene, ethylbenzene, styrene, toluene, xylenes, and butadiene. Long-term trends, temporal variations, and seasonal changes in these pollutants are examined using observational data from the Ambient Monitoring Technology Information Center. Additionally, we utilize high-resolution (4 km) simulations from the Comprehensive Air Quality Model with Extensions (CAMx) to assess the spatial distribution and air quality impacts of these emissions. Since VOCs are critical precursors to ozone formation, we further integrate ground-based and satellite observations to evaluate their influence on ozone levels.

The study found that the oil and gas industry has significantly increased VOC concentrations in the Marcellus Shale region, with VOC levels showing an upward trend, particularly from 2000 to 2015. Simulated HAP concentrations near the sources are notably higher than in surrounding regions. Additionally, HAPs have influenced ozone trends, with ozone patterns near oil and gas industry sources differing from those in other areas, especially during spring and fall. The CAMx model well captured the VOC spatiotemporal pattens. This study provides new insights into the evolving impact of oil and gas-derived VOC emissions on local air quality and offers valuable implications for emission control strategies and regulatory policies.

Associations between health endpoints and fine particulate matter species, constituents, and sources: A Systematic Review and Meta-Analysis

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Background & Objective: Fine particulate matter (PM2.5) exposure is linked to multiple health outcomes, but the specific PM2.5 constituent and source contributions to these associations remain unclear.

Methods and Approach: We included studies in English; those not conducted in vivo/animal models and in vitro/cells; those employing time-series, case-crossover, or cohort study designs; and those specifying that PM2.5 components were being analyzed. After exclusions, we performed meta-analyses for each health endpoint and PM2.5 specie/constituent/source combination if the number of studies was at least three. Two authors independently extracted data using a predefined data extraction form and assessed the risk of bias using the Risk of Bias In Non-Randomized Studies of Exposures (ROBINS-E) tool.

Results: We screened 11,388 studies and identified 229 studies meeting our selection criteria. We grouped studies according to exposure length (short-term and long-term) and cause-specific mortality and morbidity, resulting in four overarching categories: 1) short-term mortality, 2) short-term morbidity (hospitalizations/emergency room visits), 3) long-term mortality, and 4) long-term morbidity (disease incidence and birth/pregnancy outcomes). Meta-analyses revealed PM2.5 species â€“ elemental carbon, organic carbon, ammonia, nitrates, sulfates â€“ had the highest number of studies and most consistent associations with mortality and morbidity. Fossil fuel combustion-related constituents and sources were also significantly associated with multiple health outcomes, although the number of studies available was more limited.

Conclusion: Short- and long-term exposure to PM2.5 from fossil fuel combustion presents significant public health concerns. These findings underscore the need for clean air and climate action policies to focus on reducing the PM2.5 pollution from these anthropogenic sources to maximize the health benefits of those mitigation efforts.

Estimating the effects of hypothetical ambient $PM_{2.5}$ interventions on the risk of dementia using the parametric g-formula in the UK Biobank cohort

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Background: Emerging evidence identifies ambient particulate matter with an aerodynamic diameter ≤ 2.5 µm ($PM_{2.5}$) as a modifiable risk factor for dementia, but the potential health benefits gained by enacting regulations that reduce $PM_{2.5}$ remain unclear.

Objectives: Our aim was to estimate the total effects of hypothetical ambient $PM_{2.5}$ interventions starting in late life on the risk of dementia in a cohort using the parametric g-formula.

Methods: We used data from 291,495 participants in the UK Biobank cohort who were free of dementia and aged ≥ 55 years at baseline (2010). We estimated the total effects of hypothetical ambient $PM_{2.5}$ interventions (achieving annual average standards of 12 µg/m^3, 10 µg/m^3, and 9 µg/m^3) from 2010 to 2019 on the risk of dementia by calculating the difference between the estimated 10-year risk of dementia under a specified hypothetical intervention and the risk under no intervention using the parametric g-formula.

Results: Compared with no intervention, the estimated 10-year risk difference of dementia was -0.54 per 1000 population (95%CI: -1.00, -0.10), -1.36 per 1000 population (95%CI: -2.44, -0.25), -1.92 per 1000 population (95%CI: -3.39, -0.33), with $PM_{2.5}$ interventions achieving annual average standards of 12 µg/m^3, 10 µg/m^3, and 9 µg/m^3, respectively.

Discussion: The estimated 10-year risk of dementia decreased if the individual ambient $PM_{2.5}$ exposure was reduced due to more stringent $PM_{2.5}$ standards in late life compared to the natural course without intervention on ambient $PM_{2.5}$ exposure. Our findings, obtained using the parametric g-formula — a causal inference method that can directly evaluate the impact of hypothetical interventions — suggest that policies reducing ambient $PM_{2.5}$ pollution may lower the risk of dementia among UK Biobank participants who would experience more stringent ambient $PM_{2.5}$ standards in late life.

Systemic transportation of inhaled particulate matter by red blood cells in vivo

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Background: Inhaled particulate matter (PM) adversely impact on airways, lungs, and extra-pulmonary organs. One mechanism for this distant effect is translocation of inhaled ultrafine nanoparticles across the air-tissue barrier, through the bloodstream and interact with other organs, as evidenced by the detection of exogenous metal-bearing nanoparticles in healthy human placental tissue phagocytes [1]. PM exposure is associated with anemia [2], although the underlying mechanism remains unclear. Animal and *in vitro* models show ultrafine particles can adhere to erythrocytes and induce hemolysis [3]. We therefore sought evidence of i) translocation of inhaled PM and ii) PM transportation by red blood cells (RBCs) after real-life traffic emission exposure.

Methods: Informed consent (ethical reference: QME24.0041) was obtained from healthy London (UK) adults (n=14, mean age 40 years). Each participant donated blood at baseline (after remaining in an air-conditioned indoor office for 4hr), immediately following 1hr of near-main road exposure, and 1hr after returning to indoor environment. 3000 randomly selected RBCs per sample were examined under light microscopy (x60 objective). The area (mean mm^2 ±SEM) of black PM was measured using ImageJ software. Data compared using one-way ANOVA.

Results: At baseline, nano-sized black PM adherent to RBCs were observed in all participants (n=14; $8\times10^{-4}\pm1\times10^{-4}$ μm^2), with appearances compatible with carbonaceous PM. Non-adherent PM were rarely observed. The area of PM adherent to RBCs increased after near-traffic exposure ($3.1\times10^{-3}\pm7\times10^{-4}$ μm^2, $p<0.05$ vs. baseline); with no significant change between post exposure and 1hr after returning indoor ($2.7\times10^{-3}\pm7\times10^{-4}\mu m^2$, p=0.27).

Conclusion: We report the first direct evidence that inhaled nano-sized PM translocate via the bloodstream and adhere to RBCs to be transported around the body. Increase in adherent PM after 1hr of ambient exposure suggests that systemic PM dose acutely increases after traffic exposure; future *in vitro* studies on PM effect should include RBCs with adherent PM.

Air Quality and Health Benefits of Widespread Proliferation of Zero-emission Off-road Vehicles and Equipment

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Off-road vehicles and equipment have significant air quality and public health impacts due to the current reliance on diesel-fueled engines which generate high levels of pollutant emissions including nitrogen oxides and particulate matter. The off-road sector is extremely diverse and includes mobile sources used in agriculture, construction, mining, industry, goods movement, and others. The replacement of fossil-fueled internal combustion engines with zero emission technologies including battery electric and hydrogen fuel cell equipment represents a key strategy for reducing the harmful emission impacts of the sector. However, how these emission reductions translate to improvements in air quality and human health has not been quantified and characterized, including on concentrations of secondary pollutant species such as ozone and PM2.5. Therefore, in this work improvements in air quality, including ozone and PM2.5, are determined for zero emission off-road vehicle deployment using a chemical transport air quality model. Next, the health benefits associated with these changes are quantified and valued with a focus on those that occur within socially and economically disadvantaged communities. We find that the use of zero-emission off-road equipment could attain reductions in annual PM2.5 up to 1 ug/m3 and ground-level ozone up to 6 ppb in some locations. These reductions lead to monetized health benefits of up to $18.0 billion in California, with 37.3% of the total benefits occurring in socially and economically disadvantaged communities. It should be noted that the regions with the most pronounced benefits, most notably Southern California, have increased importance for air quality improvements due to 1) pre-existing degraded AQ, 2) large populations, and 3) the presence of disadvantaged communities.

JW

High-Resolution Urban Emission Mapping: Bridging Gaps Between Inventories and Hyperlocal Observations

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BACKGROUND: Emission inventories play a critical role in modeling and in designing effective policies to improve air quality. Yet, conventional inventories are assumption- and calculation-driven estimates that rarely constrained by direct observations, and do not permit routine, high-resolution quantification of emissions.

METHODS: We introduce a novel data assimilation and Bayesian inversion framework that integrates dense mobile, fixed-site black carbon (BC) measurements, and an atmospheric transport model. The outputs are hourly emissions at 150-meter (~0.02 km^2) and a local source-receptor matrix that links emissions to block-level air pollution concentrations. We demonstrate the approach in the overburdened community of West Oakland, CA.

RESULTS: We quantify hourly BC emissions per 150-m grid cell and subsequently for five key land-uses: roads, rail, port (on-land), neighborhood (residential, industrial), and ocean (ships). Results reveal sharp emissions gradients and pinpoint localized emitter hotspots previously missing from inventories. While on-road sources remains a dominant source, substantial contributions from the port and neighborhood sourcesâ€”often underestimated in conventional inventoriesâ€”are identified as important drivers of exposure. The method remains robust despite uncertainties in prior emissions, demonstrating strong agreement with independent observational data. Additionally, we establish the approachâ€™s scalability: accurate emissions estimates can be obtained using as few as 10 stationary sensors across a 15 km^2 area, complemented by time-averaged mobile data.

CONCLUSION: Our approach offers important methodological advancements and provides a scalable, data-driven framework for estimating emissions. The results can help policymakers and communities to design targeted air quality interventions. By bridging gaps between emissions inventories, real-world observations, and exposure disparities, this work strengthens accountability and informs equitable mitigation strategies

CARB’s Health Research and Programs Address Wildfire Smoke Effects

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The California Air Resources Board (CARB) works to protect the public from air pollution while developing climate mitigation strategies and initiatives. As climate change increases the frequency and intensity of wildfires, CARB prioritizes understanding health impacts and reducing exposures, particularly in vulnerable communities. The Health and Exposure Assessment Branch within CARB’s Research Division addresses these challenges through research and community outreach.

CARB prioritizes community outreach through programs like Smoke Ready California, offering resources on air quality, particulate matter health impacts, and strategies for cleaner indoor air, including guidance on selecting CARB-certified air cleaners. Under AB 2276, CARB has certified over 9,000 air cleaners meeting ozone standards. Additionally, the Clean Air Centers program, in partnership with air districts, has established over 100 facilities with upgraded air filtration as safe havens during poor air quality events.

CARB partnered with UC Irvine to address wildfire smoke concerns in the San Joaquin Valley region. The Valley includes communities that are predominantly Latino and low-income and vulnerable to climate risks. The project provided health resources and Spanish-language materials, and identified community needs, barriers, and exposure reduction strategies.

CARB’s 2022 Scoping Plan for Achieving Carbon Neutrality includes long-term land management strategies such as prescribed burning, harvesting, thinning, and fuel reduction to reduce wildfire-related $PM_{2.5}$ emissions, a major contributor to respiratory and cardiovascular diseases. CARB researchers quantified health benefits, including reduced hospitalizations, emergency visits, premature deaths, and economic benefits based on proposed actions in the plan.

Furthermore, CARB is funding research to better understand wildfire-related health impacts, including long-term effects of wildfire smoke on lung function and immune responses in primates, and short-term exposure impacts through advanced modeling and incorporating input from community engagement.

CARB will continue building on these efforts to further understand wildfire-related impacts, improve mitigation strategies, and advance community outreach and health equity.

The Effects of Exposure to Air Pollution on obesity and obesity related anthropometric measures: A Systematic review and Meta-analysis

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Background and Objectives:

The association of air pollution with body fat distribution has been studied observationally, but results have been inconclusive. The present study sought to determine the impact of ambient air pollutants on obesity and the most frequently used anthropometric measurements related to obesity.

Methods and Approach:

We searched the following databases: OVID Medline, Embase, PubMed, Web of Science, LILACS and grey literature from inception until October 30, 2023, and updated on January 23, 2024, using a comprehensive search strategy. Two independent reviewers assessed the eligibility of articles and extracted the data. A meta-analysis was conducted for all outcomes with two or more studies.

Results and Findings:

We analyzed 35 studies, of which 22 were from a middle-income country (China), and 13 from high-income countries. The meta-analysis revealed that increase in $PM_{2.5}$ (per 10 μg/m^3) and NO_2 (per 10-ppb) were associated with an increase in Body mass index (BMI) of 0.77 (95% CI: 0.56, 0.98) and 1.40 (95% CI: 0.84, 1.95) kg/m^2 respectively, with obesity odds increasing by 13% [Odds ratio (OR), 1.13 (95% CI: 1.08,1.18)] and 39% [OR, 1.39 (95% CI: 1.23, 1.57)] respectively and the obesity risk increasing by 8% [HR, 1.08 (95% CI: 1.06 to 1.11)] and 7% [Hazard Ratio (HR), 1.07 (95% CI: 0.95 to 1.22)] respectively. Moreover, $PM_{2.5}$ (per 10 μg/m^3), and NO_2 (per 10 ppb) were associated with 1.17 (95% CI: 0.58, 1.75) and 18.51 (95% CI: 5.31, 31.71) cm increase in waist circumference (WC) and increased odds of abdominal obesity by 17% [OR, 1.17 (95% CI: 1.11 to 1.23)] and 64% [OR, 1.64 (95% CI: 1.28 to 2.10)] respectively. O_3 and SO_2 showed inconsistent associations.

Conclusions and Interpretation:

$PM_{2.5}$ and NO_2 levels were positively correlated with most of the obesity-related outcomes emphasizing the importance of considering environmental factors in public health strategies.

RB

Gaussian process methods for estimating spatially-varying subgroup-specific causal exposure-response curves

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Background and objectives

In 2023, EPA issued statements indicating that mitigation of air pollution-related health inequities across racial/ethnic groups would be a key objective of future policies. Certain marginalized groups experience heightened exposure to fine particulate matter ($PM_{2.5}$) and may also be more susceptible to its adverse health impacts as a result of social structural forces. Health effects of $PM_{2.5}$ may also vary over space due to differing sources and climate patterns. Characterizing the heterogeneity in health impacts of pollutant exposures across space and groups is a critical first step to understanding how to most effectively reduce air pollution health burdens and inequities. However, doing so requires expanding causal inference methodology. In this work, we develop spatial causal inference methods to estimate spatially-varying subgroup-specific causal exposure-response curves (ERC).

Methods and approach

The proposed method integrates techniques from the spatially-varying coefficient literature for information-sharing across space and groups to address data sparsity and Gaussian processes for robust confounding adjustment. We evaluate the performance of our method in ERC and uncertainty estimation and compare to existing approaches via simulation studies. We apply it to nationwide Medicare claims data to estimate spatially-varying $PM_{2.5}$ and health ERCs for each of the three largest racial/ethnic groups in the US (non-Hispanic white, Black, and Hispanic).

Results and findings

Simulation studies reveal strong performance of the proposed method relative to several existing methods, including linear models and random forests. Preliminary area- and racial/ethnic group-specific $PM_{2.5}$ ERC estimates from the real data analysis will be shown.

Conclusions and interpretation

Our proposed Gaussian process method demonstrates promise for estimation of spatially-varying subgroup-specific causal air pollution ERCs.

Health Effects of Air Pollution in East Africa: Findings from a Scoping Review

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East Africa region is among the most populous sub-regions on the African continent, with increasing energy demand and rapid urban growth. Currently, air pollution is the second leading factor for deaths in the region, accounting for an estimated 294,000 deaths in 2021. To summarize the current scientific evidence on the health effects of air pollution in East Africa, a scoping review was conducted focusing on eight countries in the region, namely: Burundi, the Democratic Republic of the Congo, Ethiopia, Kenya, Rwanda, South Sudan, Tanzania, and Uganda.

The review protocol was developed based on the guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist. Pollutants of interest included PM_{10}, $PM_{2.5}$, NO_2, O_3, SO_2 and CO. Details on search strategy, identification of articles, study population, health outcomes, screening and data synthesis were documented in the study protocol registered on Open Science Framework (OSF).

A total of 34 publications were included in the review. 26 of the 34 publications included in the scoping review were published between 2019 and 2023. The publications explored the association between air pollution and a range of health outcomes using various analytic epidemiological study designs, including semi-ecologic, cross-sectional, cohort, and case-control designs. Overall, satellite data-based concentration estimates, and personal exposure measurements were commonly used in the studies, with 11 publications relying on satellite-derived estimates of exposure to air pollutants. 20 of the 34 publications assessed respiratory health and maternal and neonatal health outcomes including lower birth weight, miscarriage and stillbirth. Characterization of household air pollution exposures and related health effects were a major focus where several interventions were found to be successful in reducing exposure from biomass cookstoves.

Despite recent strides in availability of data, there remains a paucity of epidemiological studies on health effects of long-term exposure to air pollution in East Africa. By utilizing a variety of tools already available including passive and low-cost samplers, regulatory-grade air quality monitors, and satellite and remote sensing methods, countries in the region can expand air quality monitoring and sustain data availability. The integration of air pollution into healthcare data and systems will allow for more robust studies to be conducted to fill the gaps identified in assessment of impacts of long-term exposure to air pollution.

All publications are available on the Literature Database for Air Pollution and Health Work in East Africa (LiNDA HEWA). HEI will continue its engagements in the region to ensure that the findings of this review are disseminated to practitioners and decision makers in a way that informs and drives ambitious action towards cleaner air.

HEI

$PM_{2.5}$ in Prescribed Fire Smoke and its Impacts on Multiple Health Outcomes in the Southeastern US during 2016–2020

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Background: Prescribed fire (PF) is biomass burning conducted under controlled conditions for land management and wildfire risk reduction. Despite the care taken to disperse PF smoke (PFS), downwind communities are still exposed to significant amounts of PFS. To safeguard public health, it is essential to fully understand the impacts of exposures to PFS.

Methods: We applied a clustering algorithm to satellite fire detections to discern PF, calculated PF emissions and employed a chemical transport model and data fusion to estimate PF contributions to 24-hour average $PM_{2.5,}$ its elemental and organic carbon contents, and ozone. We then analyzed the associations of PFS $PM_{2.5}$ and ozone with non-external, respiratory and cardiovascular emergency department (ED) visits in southeastern US between 2013–2021. Utilizing a case-crossover framework, we estimated the lagged effects of exposure to PFS using conditional logistic regression, controlling for meteorology and seasonality.

Results: The average PFS $PM_{2.5}$ concentration was 0.50±0.20 µg/m^3 (mean ± standard deviation), accounting for 8% of ambient $PM_{2.5}$. About 46% of this consisted of organic carbon and 13% of elemental carbon. Average PFS $PM_{2.5}$ increased to 0.70±0.32 µg/m^3 (11% of ambient $PM_{2.5}$) during January–April. PFS $PM_{2.5}$ was associated with a relative risk (RR) of ED visits for non-external causes (1.01, 95% confidence interval (CI) [1.01, 1.02]) comparing the 95th percentile to 0 µg/m^3), upper respiratory infections (1.04, CI [1.01, 1.07]), and ischemic heart disease (1.06, CI [1.01, 1.11]). PFS ozone was associated with a RR for non-external causes (1.03, CI [1.02, 1.04]), bronchitis (1.10, CI [1.02, 1.18]), and respiratory disease (1.05, CI [1.02, 1.08]). RRs varied little across outcomes and population subgroups defined by age, sex, and markers of social vulnerability.

Conclusions: PF contributes significantly to $PM_{2.5}$ concentrations in the southeastern US. Exposure to PFS is linked to increases in ED visits for respiratory and cardiovascular diseases.

HEI energy

Compilation of 20+ Years of Oil and Gas Data for the Marcellus Shale Regions of Ohio, Pennsylvania, and West Virginia.

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ABSTRACT

Background and Objectives

The purpose of this presentation is to summarize the data collection efforts for 20+ years of well-level production and exploration, ambient air monitoring, and emissions inventory data for Marcellus Shale Regions of Ohio, Pennsylvania, and West Virginia. Due to the technological advancements in hydraulic fracturing, this part of the country has undergone a transformation of legacy conventional oil and gas production to explosive growth of unconventional oil and gas production.

Methods and Approach

Our team compiled a rich and complex set of data to evaluate spatial and temporal trends. We focused on evaluating criteria pollutant and hazardous air pollutant concentrations, and how they behaved with the trends oil and gas production and implementations of federal, state, and local regulations. Using nearby wind information, our team constructed thousands of pollution roses by year which identified geographic directions in which concentrations were highest. Additionally, emissions data from EPA's EQUATES dataset were supplemented with estimated emissions from abandoned wells, which are disproportionately high in this part of the country.

Results and Findings

Our analysis shows that in certain regions of the study area, the intersection of increased production, and implementation of air regulations provided mixed results. Although we generally observed decreases in pollutant concentrations, we also observed pollutant increases. We also evaluated the emissions impact for abandoned wells that were not originally quantified.

Conclusions and Interpretation

These datasets and integrated analyses offer researchers insights on the impacts of unconventional oil and gas development, especially in legacy areas which were originally conventional oil and gas plays.

RB

What's in the air? Engaging Native American youth in the Northern Plains to reduce air pollution

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Background and Objectives

Nationally, various groups in the USA are disproportionally exposed to air pollution. While the general US population has benefited from a decrease in air pollution levels, these benefits have not been equitably distributed. Currently less than 15% (86/576) of all federally recognized Indigenous communities operate their own approved air monitoring sites.

Our project seeks to characterize sources of air pollution and engage Native American youth in the formation of a community-based air monitoring network. We describe the approach to participatory air monitoring that engages youth in the collection, analysis, and interpretation of data that they can use to take action.

Methods and Approach

We partnered with two high schools in two Indigenous communities in South Dakota. At each high school, we engaged 2-3 students and a teacher to install QuantAQ Modulair units and PurpleAir units to measure PM1, PM2.5, PM10, CO, NO, NO2, and O3. In addition to the quantitative monitoring, the students document any air quality anomalies they observe through photographs and social media post to embrace the concept of 'ground truthing.'

Results and findings

The teams have met virtually once a month to discuss air quality patterns, share photographs of air quality events, and document findings. One team hypothesized that PM2.5 measurements would vary by time of day (i.e., morning, afternoon, and evening) and identified traffic and local field burning as sources of air quality issues. The second team hypothesized that 'red flag' warnings would coincide with worsening air quality during seasons of low precipitation.

Conclusions and interpretation

Overall, we demonstrate a method to increase local youth-centered understanding of exposure, pollution sources, and awareness to air quality.

An Emission Model for Volatile Organic Compounds from Unconventional Oil and Gas Development

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Unconventional oil and gas development (UOGD) in the US has surged in recent years, leading to significant emissions of volatile organic compounds (VOCs). Current emission models often fail to adequately represent recent UOGD practices and emission factors, especially for pre-production activities. Here we introduce the TRAcking Community Exposures and Releases (TRACER) model for pre-production VOC emissions. The TRACER model can simulate emissions of over 50 VOC species, including light and heavy alkanes, alkenes, and aromatics, from complex pre-production activities such as drilling, hydraulic fracturing, coil tubing/mill-out, and flowback, with detailed temporal resolution. The model incorporates adjustable emission factors from various sources, making it versatile for applications like emission inventory compilation, health impact assessment, and air quality evaluation.

Additionally, the TRACER pre-production model features a Graphical User Interface (GUI) to facilitate broader use in policymaking and environmental health research. We evaluated the model performance by coupling it with the dispersion model AERMOD and comparing its predictions to observations from weekly integrated and plume-triggered air samples collected near pre-production and early production operations at large, multi-well pads in the Denver-Julesburg (DJ) Basin in Colorado. The model underestimated near-pad VOC concentrations from pre-production activities using emission factors from the 2016 Nonpoint Oil and Gas Emission Estimation Tool from the EPA.

Using emission factors derived from other recent field studies in the DJ Basin, the simulated concentrations aligned well with observations for major pre-production activities, although early production VOC concentrations were still underestimated, indicating a need for further investigation. The TRACER pre-production model can be adapted for other regions but would benefit from basin-specific operational data and emission factors. Overall, the model is a unique tool to enhance our understanding of VOC emissions from UOGD, facilitating policymaking and future environmental health research.

Potential Benefits of Accelerated Turnover of On-Road Medium- and Heavy-Duty Diesel Vehicles in the United States

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Many freight vehicles continue to be operated without the most recent generation of technologies to control air pollutant emissions and also tend to be concentrated near human populations. Thus, air pollutant emissions from older medium- and heavy-duty diesel vehicles continue to affect health, and their transition to newer technologies likely carries substantial exposure and health benefits for communities residing in proximity to freight operation hotspots. Potential economic and societal opportunities *and* barriers also likely exist for owners or operators of older medium- and heavy-duty diesel vehicles.

Therefore, HEI formed an expert Heavy-Duty Diesel Vehicle Fleet Turnover Panel to provide information on the current state of knowledge on the potential exposure and health benefits, opportunities, and barriers associated with accelerated fleet turnover in the United States. The Panel is preparing an HEI Special Report with three parts: (1) an overview of the landscape of the medium- and heavy-duty diesel vehicle fleet; (2) a new case study being conducted by Dr. Daniel Horton and colleagues at Northwestern University on potential near-term effects of replacing older diesel vehicles in Chicago; and (3) a summary of findings and their implications for policy and science.

The report will describe the current and anticipated fleet characteristics and turnover rates and compare potential impacts from new medium- and heavy-duty vehicles (regardless of the specific technologies) to those from model years prior to the 2010 requirements for diesel particulate filters and selective catalytic conversion.

The Panel's report is expected to inform government and industry, identify literature gaps, and guide HEI's continuing work on the health effects of the legacy diesel fleet.

Novel Exposures, Birth Outcomes and Environmental Justice in a Changing Transportation Landscape

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Transportation–including roadway vehicles, aircraft, and trains–is a dominant source of particulate matter (PM) in many urban areas. After years of successful controls on tailpipe emissions and ongoing replacement of internal combustion vehicles with electric and other alternative-fueled vehicles, the relative contribution of non-tailpipe emissions from brake and tire wear, aircraft and trains continues to increase. To address these non-tailpipe sources, we are performing mobile monitoring downwind of Los Angeles International Airport (LAX), and stationary monitoring around trains, LAX, EV charging stations and at sites intended to elucidate the impact of brake and tire wear PM emissions. The stationary filter samples we collect will be analyzed for metals, oxidative potential, mass and black carbon. Stationary sample collection related to trains, aircraft and brake and tire wear sources are underway, as are mobile measurements downwind of LAX.

Monitoring near Direct Current Fast Charging (DCFC) stations (EV charging stations) indicate significant emissions of particles, predominantly in the submicron size range. Studies of the volatility of these particles indicate they are less volatile than typical urban particles. In contrast, particles from the gas stations the DCFC stations nominally replace produce higher volatility particles than those collected at the urban background site. Results from mobile monitoring under the flight path of the approach to LAX indicate that ultrafine particles are substantially elevated over a large swath of Los Angeles, extending at least 13 km from the airport. We will further present initial comparisons with earlier data collected around LAX.

Improving transportation emission estimates using geostationary satellite observations

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Accurate quantification of air pollutant emissions from each human activity is critical for the planning and verification of emission reduction efforts. Top-down estimates with satellite data provide important information on the sources of air pollutants. We apply a newly developed sector-based inversion method based on 4D-Var to quantify NOx, SO2, and CO emissions from transportation and other anthropogenic sources over the US. We incorporate TEMPO NO2, TROPOMI NO2 and SO2, and MOPITT CO observations and leverage the co-emission of these gases to identify the source sectors. Our posterior NOx emissions are 20-40% higher than the National Emission Inventory (NEI), suggesting an overprediction of the decrease of NOx emissions from the US EPA. The top-down estimates suggest that emissions from the transportation sector are underestimated in the NEI over the east coast of the US, but overestimated in the Midwest. This framework improves emission estimates at the process level by optimizing emission factors and activity rates without relying on explicit knowledge of their values and resolves discrepancies with bottom-up inventories at the sector level.

Considerations for Assessing Cumulative Exposures for Oil and Gas Communities in the United States: a Roadmap for Evaluating Adverse and Beneficial Environmental, Social, and Economic Factors that Affect Human Health

Yasmin Romitti, Gabriela Daza, Donna Vorhees, Cloelle Danforth, Anna Rosofsky, and Ellen Mantus, Health Effects Institute

The health of people living in any community can be affected by an array of environmental, social, and economic factors. There are numerous studies throughout the scientific literature documenting how exposures associated with one or even a few of these factors might affect human health. The same is not true for understanding how the integrated (or, cumulative) exposure to all these factors can affect health. With guidance and oversight from a Special Panel of external experts, HEI Energy has developed a roadmap for assessing cumulative exposures through the process of cumulative impact assessment (CI assessment). The roadmap uses the context of oil and gas communities in the United States to illustrate the concepts and process of CI assessment., but it can be adapted to any decision context. CI assessments can help to reframe scientific and policy discussions so that they encompass the full spectrum of factors that can affect human health, and in so doing, position decisionmakers to capitalize on beneficial effects while avoiding adverse effects.

Pollution prediction in diverse policy applications: The case of fine particulate matter

Dickinson, AJ (Oregon); Rubin, EA (Oregon)

Background/Objectives:

Environmental monitoring is essential for understanding air quality, human health, policy effectiveness, and environmental justice. However, traditional monitoring networks have limited coverage, particularly for pollutants like fine particulate matter (PM). Advances in remote sensing and machine learning (ML) offer promising alternatives for researchers and policymakersâ€”predicting at spatiotemporal high resolution. Accordingly, environmental health, policy, and economic research have quickly embraced this novel view of previously unseen pollution.

Methods:

We evaluate a common PM-prediction approachâ€”monthly ML-based estimates that use in-situ measurements, remotely sensed data, chemical-transport-model outputs, and spatial lags. After replicating existing benchmarks, we assess how methodological choices affect accuracy and downstream analysesâ€—including air-quality-standard compliance and racial/ethnic disparities. We compare standard cross-validation (better for interpolation) with spatial cross-validation (better for extrapolation) and examine how prediction errors, biases, and uncertainty influence downstream applications.

Results:

While ML-based PM models report high accuracy (R-squared > 0.8), their performance varies by application. Standard validation methods can overstate accuracy, particularly for policy-relevant tasks like predicting pollution in unmonitored areas far from the nearest monitor. Further, uncertainty in PM estimates significantly impacts causal inference and environmental justice analyses, sometimes reversing key relations.

Conclusions:

Predicted datasets are powerful tools but include uncertainty and bias. Models train for specific applications. Downstream use should reflect these points. Our results highlight the need for careful training/validation tailored to specific research and policy contexts. We recommend best practices for improving predictive modeling and propose an open-source framework to help researchers generate more context-appropriate predictions. By refining ML-generated predictions, policymakers and scientists can make more informed decisions about air quality and its broader impacts.

HEI energy

Elucidating Vulnerability and Risk of Domestic Well Waters to Impairment from Spills Associated with Unconventional Oil and Gas Development in the Marcellus Region

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Nearly 20,000 unconventional oil and gas wells have been drilled in the Marcellus region. This unconventional oil and gas development (UOGD) involves management of large volumes of freshwater, drilling and hydraulic fracturing fluids, and produced water. Spills of these materials on or near UOGD well pads have been implicated as sources of chemical impairment of residential drinking-water wells. Motivated by this concern, our study seeks to elucidate the ways that hydrologic vulnerability and UOGD-related spills combine to affect the chemistry of residential well waters across the Marcellus region.

This research is guided by three aims: (i) to advance a framework suitable for quantifying the spatial distribution of vulnerability, defined here as the likelihood of a contaminant reaching a drinking-water well if it were spilled from a UOGD well pad; (ii) to quantify the spatial risk of well-water impairment by considering vulnerability in context to data on UOGD-related spills; and (iii) to evaluate associations between UOGD chemical fingerprints in well-water samples, vulnerability, and UOGD spills. We address these aims through hydrologic modeling to estimate vulnerability, analysis of UOGD-related spills that shape risk and are documented by state-regulatory agencies, and by application of logistic regression models to test relationships between spills, vulnerability, and the presence/absence of UOGD chemical fingerprints inferred from analyses of published water-quality observations. Our findings indicate that nearly 150,000 residents of the Marcellus region rely on household water wells that are hydrologically vulnerable to UOGD contamination, although a small fraction of these people depend on water wells that are hydrologically connected to UOGD well pads where spills have been documented.

Results of our statistical analyses, although not finalized, reveals a 25% increase in the interaction between hydrologic vulnerability and spill occurrence is associated with a 6% increase in the odds of a well-water sample exhibiting a UOGD-chemical fingerprint.

Development of a Land Use Regression Model for the Exposure Assessment to Ultrafine Particles for Epidemiological Studies in Japan

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Tsuyoshi Ito, (Environment Research Division, Japan Automobile Research Institute)

Satoshi Nakai, (Graduate School of Environmental and Information Sciences, Yokohama National University)

Background: Conducting reliable UFP epidemiological studies necessitates the development of appropriate exposure assessment methods. In Japan, spatial distribution of UFP which can be used for exposure assessment in epidemiological studies has not been studied. The purpose of this study was to develop a LUR model for UFP epidemiological studies in Japan.

Methods: UFP concentrations (particle number concentrations: PNC) were measured at 31 sites in Yokohama City, Kanagawa Prefecture, Japan (approximately 24 km east to west and 31 km north to south) during spring, summer, autumn, and winter of 2023 (total 157 observations), and annual mean concentrations were obtained at each site. A portable particle counter (CPC3007, TSI) was used for the measurement at least once per season, for 30 minutes from 9:00 to 16:00 on weekdays, at each site. LUR modeling utilized 156 potential geographic predictors including: land use, traffic volume, population and others. A leave-one-out cross-validation procedure was used to evaluate the model performance.

Results: The mean annual UFP concentration at the 31 sites was 22,900 particles / cm3 (standard deviation = 7,200). The adjusted R2 for a LUR model developed in this study was 0.66, and the adjusted R2 for leave-one-out cross validation was 0.56. Those values were similar to the previously reported value for UFP-LUR model. The LUR model estimated that UFP concentrations tended to be higher near the coast and also near major roads in Yokohama city.

Conclusion: In this study, we developed a LUR model that can be utilized for the exposure assessment to UFP in epidemiological studies conducted. It is our intention to undertake an epidemiological study that utilizes the developed LUR model.

Determinants of Indoor/Outdoor Ratio- A machine learning approach to reanalysis of existing data

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Ambient air pollution has long been used as a proxy for personal exposure in determining the health risks posed by poor air quality, primarily due to the difficulty of accurately measuring personal exposure. Considering humans increasingly spend most of their time indoors, understanding air quality in indoor environments like homes, schools, and offices has become increasingly important. The indoor/outdoor (I/O) ratio of pollutant concentrations has often been used to investigate the influence of outdoor sources on the indoor environment. While the ratio is simple to calculate, its value depends on several variables, including type of pollutant, gaps in the building envelope, type of ventilation, human behavior, indoor sources, etc. A select few studies have reviewed I/O ratio literature to understand the variability and the determinants, for example, Chen and Zhao (2011), Salonen et al. (2019), and Hu and Zhao (2020). In our study, we advance this analysis using multiple machine-learning methods, viz., multiple linear regression, regression-classification trees, and random forest. We present a statistical analysis of the I/O ratios of PM2.5 and NO2 compiled from previous reviews and our literature search. Our approach is statistically more accurate in understanding determinants of I/O ratios. It addresses statistical inadequacies in some prior studies that do not account for confounding variable bias. A statistically robust approach to interpreting the I/O ratio is useful beyond future scientific studies. We are witnessing increasing availability of ambient air pollution data and decreasing costs of measuring indoor air quality, which enables more people to compare indoor and outdoor pollutant concentrations. Our meta-analysis of existing evidence also yields insights for lowering the I/O ratio, thereby reducing the effect of outdoor pollution sources on indoor air quality.

HEI energy

Passive Sampling Derived Toxic Hydrocarbon Abundances Across a New Mexico Frontline Community in the Permian-Delaware Oil and Gas Production Basin

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Background and Objectives. Health effects from air pollution are well-characterized for a number of air pollutants that are monitored in densely populated areas. However, limited air quality monitoring is performed in less densely populated areas. As such, air pollution from oil and gas production, which typically occurs in rural areas, is potentially hazardous to frontline communities. In these communities, toxic hydrocarbon emissions such as benzene are a concern.

Methods and Approach. With the help of local community volunteers, we collected non-methane hydrocarbon (NMHCs) concentrations through a passive monitoring network near residences in the Carlsbad-Loving, New Mexico area of the Permian Basin. The 7-day integrated samples were analyzed to capture the spatial distribution of NMHCs to better understand population exposures to UOGD activities. One of the passive monitoring sites was co-located with a stationary monitoring station located in Loving, NM, that continuously collected time-resolved data on NMHCs. We compare the concentrations from these sites as well as similar time-resolved measurements taken in four Texas cities.

Results and Findings. Data from the passive monitors spanned an approximately 200 km^2 area mostly south of Carlsbad show that petroleum hydrocarbon levels vary with proximity to and surrounding density of potential emission sources. Average week-long concentrations of benzene varied from as low as 0.1 ppb at a site away from sources in summer to as high as 1.5 ppb at a site close to sources in winter. The across-network mean and median levels were two to three times higher than benzene concentrations in large Texas cities. The strong positive correlations of benzene with petroleum alkanes suggest co-emissions during regional hydrocarbon production and storage, such as from gas or liquids tank venting processes. Similar results were obtained in the Eagle Ford shale.

Conclusions and Interpretation. Our findings point to regional emissions as a driving factor of elevated levels of NMHCs. Certain air toxics in this rural community are no longer driven by traffic, but by direct emissions from oil and gas industry sources.

Air Quality Trends in Texas as associated with Unconventional Oil and Gas Development (UOGD)

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Background and objectives. Unconventional oil and gas development (UOGD) has created a new emissions source of hydrocarbons and nitrogen oxides. This has affected air quality in regions where production is centered, including four different shale areas in Texas. While air quality monitoring (AQM) in rural areas is rare, the Texas Commission on Environmental Quality (TCEQ) maintained or initiated AQM stations in or downwind of the Haynesville and Barnett gas producing shales, as well as the Eagle Ford and Permian basin oil producing shales. Our primary objectives were to use these AQM station data to estimate the industry's changing emissions over time. Our secondary objective was to use satellite-based measurements of tropospheric formaldehyde (HCHO) as a proxy for hydrocarbon emissions in the Permian basin, where AQM station data are most sparse.

Methods and approach. Quality-assured data from nine TCEQ AQM stations were used with a focus on ethane, propane, and benzene. OMI L3 data were analyzed from 2004 to 2022. Trends were determined using various splines on a compound's time series or on non-negative matrix factorization (NMF) derived factor coefficients.

Results and Findings. Haynesville shale AQM station data display no conclusive trend, show higher hydrocarbon levels before shale production began, then a sharpe drop into 2012. Barnett shale data show no consistent trends, increasing at some AQM stations, dropping at others. Eagle Ford and Permian basin data show trends that correlate with regional production data, mostly oil and associated gas production. Peaks occurred in 2014 (Eagle Ford) and 2019 (Permian). OMI data provided a similar picture, showing rapid growth of HCHO during the 2015-2019 boom in the Permian, then leveling.

Conclusions and interpretation. The shale gas production regions in Texas differ from the shale oil production regions. While no regulatory effects are observable in the air quality data, discerned trends appear to follow oil production and gas flaring volumes.

JW

Inhaled Vitamin D as a Protectant Against Vitamin D Deficiency-Induced Air Pollution Sensitivity

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Background: People of color are disproportionately affected by environmental lung diseases and respiratory infections. This has been hypothesized to be due to increased prevalence of vitamin D deficiency (VDD) among people of color. Our lab has also recently shown that lower vitamin D levels may lead to worse outcomes after acute exposure to ozone, a prevalent global oxidant air pollutant. Interestingly, while vitamin D has been proposed as a treatment for the pulmonary effects of VDD, studies of oral vitamin D supplementation for the treatment of lung disease have produced mixed results. We therefore investigated the role of vitamin D inhalation in protecting against ozone exposure.

Methods: We exposed primary human bronchial epithelial cells (HBECs) at an air-liquid interface to ozone following administration of vitamin D to the basolateral or apical compartment. Apical treatment was delivered via aerosol in a novel multi-well in vitro exposure system while basolateral treatment was added in the media. For mechanistic investigation, 16HBEs with fluorescent probes of oxidative stress and lipid peroxidation were pre-treated with vitamin D before exposure to ozone.

Results: We found that pretreatment with vitamin D reduced the ozone-induced secretion of the pro-inflammatory cytokine, IL-8. RNA-sequencing and gene set enrichment analysis (GSEA) revealed that vitamin D treatment reversed ozone-induced increases in inflammation, oxidative stress, and immune dysfunction genes/pathways. In our 16HBE model, vitamin D pre-treatment was found to attenuate markers of oxidative stress induced by ozone.

Conclusions: Despite the established links between circulating vitamin D and respiratory health, no studies have investigated the use of vitamin D inhalation as a protectant against air pollutant-induced pathological responses. Our data suggest inhaled vitamin D may be a feasible therapeutic strategy for treating the pulmonary effects of VDD and may have utility in reducing and preventing health disparities associated with lung diseases.

Assessment of Changes in Air Quality in India since the National Clean Air Programme

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Air pollution is the leading risk factor for deaths in India and exposure to $PM_{2.5}$ continues to be a concern. In 2019, India launched the National Clean Air Programme (NCAP) with a targeted reduction of 20%–30% in PM_{10} and $PM_{2.5}$ concentrations by 2024; in 2022, the target was revised to reduce PM_{10} levels by up to 40% by 2025-26. This analysis aims to assess the changes in levels of PM_{10} and $PM_{2.5}$ between 2017 and 2024.

For the assessment, real-time PM_{10} and $PM_{2.5}$ data from regulatory stations and meteorological data from the ERA5 reanalysis dataset was used. All analysis was conducted using R. Multiple scenarios were tested, including exceedance of the annual Indian National Ambient Air Quality Standards (NAAQS), changes in annual averages between 2017 and 2024, and analysis of trends for PM_{10} and $PM_{2.5}$ with and without weather normalization.

Since the launch of NCAP, the availability of real-time stations has increased by more than 100%, bolstering the availability of data on PM_{10} and $PM_{2.5}$ across major cities. Overall, single-station averages provided more meaningful insights on changes in levels of PM_{10} and $PM_{2.5}$ when compared to the citywide averages, especially since the number of monitoring stations has varied significantly over the years. Assessment of annual exceedance against NAAQS provided inconsistent results across stations and was not reliable for capturing long-term trends. Trend analysis also showed inconsistent results across cities.

Despite the increase in the number of stations since 2019, for most cities, data is only available for the past two or three years. In cities where reductions were observed, trends often relied on data from a single station. Furthermore, since long-term data are not yet available and there is limited availability of data on sectoral emissions, and there have been multiple policy interventions around similar time frames, the impact of NCAP on air quality changes cannot yet be easily attributed.

Quantification of residential particulate pollution using low-cost sensors and the perception of air quality in Ibadan, Nigeria.

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Air pollution is a major cause for morbidity and mortality. In LMICs where air pollution levels are often high due to rapid urbanization and limited environmental regulations, peopleâ€™s perception may help understand local views, daily behaviour and policy advocacy. This study was carried out using online survey completed by 182 respondents residing in Ibadan city. The responses from the survey were used for evaluation of the perception of air quality among the participants. Descriptive analysis was performed , and thematic analysis was used to code free text data. In addition, PurpleAir sensors were used for in-situ measurements both indoors and outdoors in two households over a seven-month period to connect perceptions of air quality with actual concentrations. We recorded PM2.5 daily geometric mean of 43.7 ±2.0 and 50.0 ±1.9 µgm-3 for indoor and outdoor, respectively. Levels above WHO daily recommended limit of 15 µgm-3 was exceeded throughout the study. Air quality was primarily perceived as “moderate” both indoors and outdoors while the actual in-situ measurements suggested air quality status to be “very bad” within the city. Majority of the respondents (94.5%) agreed they are aware air pollution cause ill effects on children. Qualitative analysis suggested a concern on insufficient enforcement of policies aimed at reducing pollution, the negative impacts on their children’s health and its financial implication.

Prenatal and postnatal exposure to ambient fine particulate matter (PM2.5) and risk of autism spectrum disorder and attention-deficit/hyperactivity disorder among Medicaid recipients

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Background and objectives: Evidence on the association between prenatal and early life exposure to fine particulate matter (PM_(2.5)) and risk of autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD) is conflicting. In particular, studies in low socioeconomic status populations are lacking. We aimed to conduct a longitudinal study to assess potential associations and possible windows of susceptibility for ADHD and ASD due to increased ambient PM_(2.5) exposures.

Methods and approach: We created a mother-infant longitudinal cohort using the Medicaid Analytic eXtract (MAX) database from 2001-2013. Cases of ASD and ADHD were identified via ICD-9 codes. Ambient prenatal and postnatal exposure to PM_(2.5) was assigned via a spatiotemporal pollutant prediction model at the motherâ€™s residential zip code. Distributed lag non-linear models were used to characterize PM_(2.5) exposures (prenatal: 0-to-37-week lag; postnatal: 0-to-3-year lag). Cox models were stratified by county and birth year and adjusted for demographics, behavioral risk factors, ambient temperature, season of conception and area-level socioeconomic status (SES).

Results and findings: A total of 1,548,303 births were included. A 10 ug/m3 increase in average weekly prenatal PM_(2.5) exposure was associated with 1.09 (95% CI: 0.95-1.25) and 1.24 (95% CI: 1.18-1.30) hazard of ASD and ADHD, respectively, at the cumulative lag (0-37 weeks). A 10 ug/m3 increase in average annual postnatal PM_(2.5) exposure was associated with 1.03 (95% CI: 0.76-1.40) and 0.87 (95% CI: 0.74-1.02) times the risk of ASD and ADHD, respectively, at the cumulative lag (0-3 years).

Conclusions and interpretation: Low-income children in the US may have higher ADHD risk due to increased prenatal PM_(2.5) exposure. Although there is a potentially sensitive window of exposure in late pregnancy for ASD, cumulative prenatal and postnatal PM_(2.5) exposure was not associated with ASD risk.

Long-term exposure to black carbon and adult-onset asthma and COPD incidence in two Danish nationwide cohorts: Effects Beyond $PM_{2.5}$ and NO_2

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Background: Epidemiological evidence on health effects of black carbon (BC), especially for obstructive airway diseases, remains limited.

Objectives: We investigated the association of long-term exposure to BC as well as fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2) with adult-onset asthma and chronic obstructive pulmonary disease (COPD) incidence in two Danish nationwide cohort: the Danish Nationwide Administrative Cohort (DNAC) and the Dansh Nurse Cohort (DNC).

Methods: We followed 28,731 female nurses (aged >44 years) in DNC from 1993/1999 and approximately 3 million of all residents (aged >30 years) in DNAC from 2000 until the end of 2018 for first hospital contact for asthma or COPD. Annual mean concentrations of air pollutants were estimated using Danish AirGIS modeling system for DNC and European-wide hybrid land-use regression models for DNAC. Cox proportional hazard models were used to investigate association with each pollutants, with adjustment for lifestyle factors, and individual and area level socioeconomic status.

Results: Over a mean follow-up of 16 years in DNAC and 23 years in DNC, we identified 52,648 asthma and 146,269 COPD cases in DNAC, and 633 asthma and 1,145 COPD in DNC. Per interquartile range increase in BC ($0.5\times10^{-5}m^{-1}$ for DNAC; 0.34 $\mu g/m^3$ for DNC), the hazard ratio (HR) was 1.18 (95% confidence interval, 1.15-1.21) for asthma and 1.08 (1.06, 1.09) for COPD in DNAC, and 1.06 (1.00-1.13) for asthma and 1.04 (0.98, 1.11) for COPD in DNC. Increased risks were observed with NO_2 in both studies, while those with $PM_{2.5}$ were only observed in DNAC.

Conclusion: Our study suggests that long-term exposure to combustion-related pollutants, such as BC and NO_2, is associated with an increased risk of asthma and COPD. These findings underscore the need for further research and targeted air quality regulations to mitigate these health impacts.

Roadmap for MHDV fleet renewal: A Chicago case study on Air Quality and Public Health impacts of fleet conversion with multi-stakeholder engagement

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Abstract

Background and objectives. Plans to significantly reduce diesel-fuelled Medium and Heavy Duty Vehicle (MHDV) emissions in the coming years cannot rely solely on natural fleet turnover. With projected increases in freight volumes, transitioning to lower-emission MHDV is crucial for long-term emission reduction and health impact mitigation. This research aims to (1) identify the Chicago communities most burdened by MHDV emissions, (2) characterize the air quality, public, health, and spatial disparity related to MHDV activities, (3) explore challenges and opportunities for MHDV fleet turnover by engaging with the logistics and warehousing industries, as well as residents of the impacted communities.

Methods. We propose using state-of-the-science numerical modeling coupled with participatory stakeholder behavior research. This approach enables 1) neighborhood-scale characterizations of air pollution exposure and health disparities, 2) gathering relevant insights from various industry stakeholders and communities, and 3) identifying optimal incentives and strategies to motivate accelerated MHDV fleet renewal.

Results. Our findings reveal a robust identification of air quality and public health burden hotspots in several Chicago Communities. Ongoing work is advancing air pollution modeling science to account for elevated concentrations of MHDV activities and emissions in communities near warehousing facilities. Through stakeholder engagement, we are uncovering a complex array of decision criteria, barriers, and trade-offs related to fleet conversion drivers.

Conclusion. The assembly of an interdisciplinary team of scientists, engineers, policymakers, and industry and community representatives is central to identifying pathways for MHDV fleet renewal. By relying on knowledge co-creation, we can assess the efficacy of MHDV fleet renewal in reducing exposure and health disparities, and identify optimal incentives and strategies through collaborative efforts.

JW

Compounding Effects of Wildfire-Specific $PM_{2.5}$ and Baseline Vulnerabilities on Pediatric Asthma in Northern California

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Background: Wildfire smoke events have increased in severity and impact over the past two decades due to climate change and are expected to remain a major contributor to air pollution in the U.S. These events disproportionately affect vulnerable populations, including children, the elderly, and communities with pre-existing environmental and socioeconomic disadvantages.

Methods: In this retrospective study, we evaluated the association between wildfire-specific $PM_{2.5}$ exposure and asthma-related hospitalizations among children in Alameda and Contra Costa Counties, California, from January 2017 to February 2020. We analyzed data from over 9,300 hospital visits at a regional children's hospital using a distributed lag quasi-Poisson regression model to assess short-term impacts up to six days post-exposure.

Results: Baseline risk, estimated through random intercepts in the model, exhibited spatial patterns consistent with established risk indicators like CalEnviroScreen, suggesting heightened underlying vulnerabilities. When wildfire-specific $PM_{2.5}$ exposure was included in the model, we observed a compounding effect on health outcomes. Specifically, each 10 $\mu g\ m^{-3}$ increase in wildfire-specific $PM_{2.5}$ was associated with a 4% increase in pediatric hospitalization risk on the day of exposure, with additional 3–4% increases on days 3 and 4. Cumulatively, these exposures corresponded to an 8% increased risk over the six-day lag period.

Conclusion: Notably, wildfire-related health risks were amplified in communities with higher baseline vulnerability. These findings underscore the compounded health burden of wildfire smoke in communities already facing environmental and socioeconomic disadvantages, emphasizing the need for targeted public health interventions in high-risk areas.

HEI energy

Spatiotemporal Investigation of VOCs, Trace Gases, and Particulates in the Permian Basin: Insights from Mobile and Stationary Measurements

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Volatile organic compounds (VOCs) from unconventional oil and gas development (UOGD) present notable yet underexplored effects on air quality and public health, due to uncertainties in mixing ratios, atmospheric lifetimes, reactivities, and toxicities. This study examines spatiotemporal measurements of VOC mixing ratios in the Permian Basin, among the most productive oil and gas regions in the United States, spanning west Texas and southeastern New Mexico. From April 29 – May 12, 2024, we conducted an intensive field campaign involving mobile and stationary measurements as part of the HEI Energy extension project. A Vocus Proton Transfer Reaction Time-of-Flight Mass Spectrometer (Vocus PTR-TOF-MS) measured a broad range of VOCs at 1 Hz, while additional instruments on an electric van measured methane (CH_4), ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), black carbon, and hydrogen sulfide (H_2S).

Mobile observations revealed **both** broad and localized areas with elevated pollutant concentrations, capturing short-lived and relatively **unabundant** species. The highest mixing ratios appeared in near-source plumes downwind of UOGD sites, with methane (57 ppm), hydrogen sulfide (481 ppb), and benzene (197 ppb). The **mixing ratio** of a near-source plume decayed exponentially with distance. Stationary measurements also detected plumes with correlated VOCs elevations, pinpointing downwind emission sources from oil and gas facilities. Observations captured **significant** spatiotemporal variability in chemical composition, elucidating hotspots near UOGD operations.

In addition to mobile measurements, we conducted a two-day co-location study at a continuous monitoring site in Loving, New Mexico, to compare and complement measurements using different techniques.

Overall, our results show how local and regional emissions influence air quality and ozone formation in an oil and gas extraction region. This work advances understanding of **spatiotemporal variability in chemical composition and air quality impacts** of UOGD in the Permian Basin, informing strategies to mitigate pollution and safeguard public health.

AirMail: Utilizing Data Science to inform Environmental Health & Community Advocacy in Houston

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Air Alliance Houston

Background: Houston lacks adequate zoning laws, and industrial facilities can operate within residential areas, exposing historically marginalized communities to harmful air pollution. The existing mechanisms diminish public participation, prioritize economic growth over public health, and deprive residents of agency over their community's air quality.

When a permit application is filed, the community has 30 days to express their concerns to the Texas Commission on Environmental Quality (TCEQ), which approves, denies, or amends the permit. However, this information is not readily available to communities.

Methods: We partnered with a data science firm to develop AirMail to address this social challenge. AirMail displays new permit notices for air, water, and solid waste on an interactive real-time map. To create this, we profiled permit notices, drafted classification metrics for auto-categorization, imported county address data, geolocated permit-seeking facilities, and integrated mailing capabilities into the program framework. Using AirMail, we sent postcards to 70,834 residents living close to industries who applied for air permits in 2024. The postcards provided resources, timelines, and guidance on engaging in the public participation process.

Results: Before creating AirMail, public meetings were scarcely scheduled, and community participation in these public meetings was low. However, public meetings, attendance, and participation have increased after creating and utilizing this tool. In 2024, 18 air permits were organized against using AirMail. 10 public meetings on air permits initiated by an AirMail campaign were granted and held, with one permit successfully achieving a motion to overturn and 4 active permits awaiting meetings. Postcard recipients submitted 1,730 online public comments with personal accounts of industrial negligence, health effects of exposure to emissions, and calls for stronger regulations.

Conclusions: This tool empowers fenceline communities to advocate for better air quality. AirMail currently covers all the counties in Texas but can be tailored for use in other states.

Energy Efficiency & Human Health: a Case Study to Illustrate the Human Health Benefits of Industry Sector Technological Improvements

Donna Vorhees, Ellen Mantus, Gabriela Daza, Health Effects Institute

With this project, HEI Energy seeks to support heavy industry and other sectors of the U.S. economy by providing an understanding of the human health benefits that accompany industrial process improvements that involve increasing energy efficiency. Quantifying these benefits will be critical for engaging with people who live and work in host communities and conveying the value of projects for achieving economic and health goals simultaneously. Given the complexity surrounding process improvements that include decarbonization, HEI Energy is pursuing a two-phase approach in coordination with the company implementing the improvements and in consultation with the host community: Phase I: Develop the technical approach to assess the health benefits for a single industrial sector case study, and Phase II: Implement the technical approach. HEI Energy is now in Phase I, at work with oversight by an expert Special Panel to identify a promising industrial project to serve as a case study. The Special Panel will develop a technical approach for assessing the case study's health benefits in a way that can help to maximize these benefits while achieving the project's intended goals and avoiding unintended adverse health consequences. HEI Energy plans to implement the approach in Phase II and measure and report on the actual health benefits.

Exploring the spatio-temporal information in a US-wide dense low-cost sensor network

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Fine particulate matter (PM2.5) poses significant public health risks, but local variabilities in exposure remain obscured due to the limited spatiotemporal information from the traditional monitoring approaches. Leveraging the dense spatial coverage of PurpleAir sensors across the U.S. and the robustness of government-managed reference sites, this study develops a spatiotemporal resolved empirical air quality model aimed at refining PM2.5 observations at sub-kilometer scales with hourly temporal granularity. This study focuses on the ten most populous metropolitan statistical areas in the U.S., covering 25% of the nation's population. After preliminary data cleaning and quality assurance, we developed a â€˜remote collocationâ€™ protocol to calibrate the dense low-cost sensor network with nearby reference stations. The process of identifying remote collocation data involves three steps: delineating buffer range for geo-matching, filtering sensors based on performance and concentration trends, and selecting specific time periods where the reference monitoring network sees similar regional PM2.5 signals. Subsequently, the data recognized within the designated spatiotemporal range are treated as directly regression-calibrated sets, followed by a comparative analysis of various calibration algorithms, with the resulting coefficients applied to indirectly calibrated sensors. Results demonstrate that calibration using multiple linear regression, incorporating temperature and humidity as independent variables, achieved the most robust performance. Finally, we capture PM2.5's local temporal variability using hourly Kriging further, revealing significant intra-urban exposure disparities while reproducing its spatial variability using a land use regression-based empirical model. This study highlights the feasibility and practicality of low-cost sensors in pinpointing dynamic hotspots at scale. The detailed and reliable PM2.5 estimates generated by the proposed methodology can be applied to enhance exposure assessments, detect community pollution sources, and inform the development of air pollution mitigation policies to reduce environmental inequities.

Impact of London's Ultra Low Emission Zone on lung development in children: results from the Children's Health in London and Luton (CHILL) cohort study

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Background and objectives: Traffic-related air pollution (TRAP) harms children's lung development; suboptimal lung growth is a risk factor for chronic lung disease. Cities are introducing Clean Air Zones (CAZs) to reduce TRAP, but their health impacts are poorly understood. London's Ultra Low Emission Zone (ULEZ) was implemented in 2019, providing a natural experiment to assess these impacts. We hypothesized that improved air quality arising from ULEZ implementation would improve lung growth trajectories of children living in London.

Methods and approach: We established a cohort of 3,414 schoolchildren aged 6-9 years in London and Luton, a distant control site with comparable demography and air pollutant mix. We visited schools to conduct annual spirometry, starting the year before ULEZ implementation (2018-19) and for 4 years of follow up (2019-20 to 2022-23). Mixed effects regression models examined the relationship between modelled air pollution exposures and lung function growth (increase in forced expiratory volume in 1 second, FEV_1) over the study period.

Results and findings: 3,209 children (94%) had at least 1 successful FEV_1 measurement and were included in the analysis. At baseline, FEV_1 was significantly lower in London than Luton (-38ml, P<0.0001). However, FEV_1 growth was greater in London than Luton (233 vs 223ml per year, P<0.0001) and after 4 years FEV_1 was similar (2283ml in London, 2282ml in Luton). Modelled annual exposure to NO_2 decreased faster in London than Luton (3.77 vs 1.77µg/m^3 per year, P<0.0001). Across the cohort, an IQR decrease in NO_2 (16.5 µg/m^3) was associated with an increase in FEV_1 growth of 16.5ml per year (P<0.0001).

Conclusions and interpretation: Children in London had significantly lower lung function before ULEZ implementation, but subsequently experienced faster lung growth than those in Luton, achieving similar lung function after 4 years. This novel evidence of reduced NO_2 exposures associated with accelerated lung development supports wider implementation of CAZs as a public health intervention.

Chemical composition of fine particulate matter emitted from electric vehicle fast charging stations

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Background and objectives: The global shift to electric vehicles necessitates the expansion of Direct Current Fast Charging (DCFC) stations, yet the related environmental and public health impacts remain unclear. Here, we report that the power cabinet at DCFC stations emit fine particulate matter (PM_ (2.5)).

Methods and approach: We collected integrated filter samples from 50 DCFC stations across 47 cities in Los Angeles County, California. To understand the emission mechanism of these particles, we measured real-time PM_ (2.5) mass concentration, particle size distribution, and other pollutants, as well as characterized particle chemical compositions on integrated filter samples.

Results and findings: The daily PM_ (2.5) concentrations were between 7.3 and 39.0 Âµg m-3, significantly higher than urban background sites ($p = 0.02$) and the nearest U.S. EPA monitoring stations ($p < 0.0001$). Our results indicate that these particles, primarily in the sub-micrometer range (0.5â€“1.0 Âµm), are likely due to particle resuspension from the power cabinets. PM_ (2.5) samples from power cabinets showed higher levels of brake and tire wear tracers (Ba, Cu, Zn) and dust tracers (Ca, Al, Fe) compared to samples from nearby chargers and background sites.

Conclusions and interpretation: Our study highlights an urgent concern regarding PM_ (2.5) emissions from DCFC stations. The focus on an underexamined emission sourceâ€”power cabinetsâ€”provides valuable insights into the potential unintended consequences of electric vehicle infrastructure. These novel particles differ fundamentally from other ambient particles, with largely unknown toxicity and health effects. With no current emission standards for DCFC, managing particle resuspension is crucial for improving air quality and protecting public health as transportation electrification advances.

HEI energy

Trends in Exposure to Air Pollutants from Unconventional Oil and Gas Activity and Other Sources in the Marcellus-Utica Region, Exposure in Context, 2004-2023

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Background and Objectives

Oil and gas operations are just one of the sources of emissions in the Marcellus-Utica region. Understanding the contributions of these and other sources to regional air pollution is critical for assessing overall exposure risks. Populations already at risk from other industrial activity can be more susceptible to health hazards resulting from additional pollutant exposure than those in other areas. This study integrates ground-based and satellite observations to evaluate trends in air quality from 2004 to 2023, contextualizing oil and gas emissions within broader regional pollution influences.

Methods and Approach

We developed a series of machine learning models to estimate pollutant concentrations using satellite remote sensing, ground measurements, and emission inventories. Specifically, we used remote sensing instruments: Moderate Resolution Imaging Spectrometer (MODIS), Ozone Monitoring Instrument (OMI), and the Tropospheric Monitoring Instrument (TROPOMI) to train random forest, extreme gradient boosting (XGBoost), light gradient-boosting machine (LightGBM), and residual network (ResNet) models for $PM_{2.5}$ estimation, and a ResNet-based convolutional neural network for NO_2 estimation. Key sources of additional training data included hourly power plant emissions, daily oil and gas activity, monthly gas production, 3-yr annual reported emissions for traffic and other industrial sources.

Results and Findings

Emissions from oil and gas development play a relatively small role in the overall region's air quality, and at times regional pollutant concentrations are dominated by external sources like Canadian wildfires and other long-distance emitters. The geographic nature of oil and gas development has changed the populations exposed as compared to earlier years.

Conclusions and Interpretation

Overall, regional pollutant concentrations have generally been improving throughout this period because of technological and policy changes. Some of these changes are likely to be due to increased natural gas availability and the decline of coal use, improvements in vehicle emission standards, and other similar factors.

JW

Sources of Ozone, Particulate matter and Their Precursors in the El Paso Area

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The region of El Paso, Texas, is frequently affected by haze, with particulate matter (PM) concentrations often exceeding established air quality standards, raising concerns about human exposure and public health. Emissions of particulate matter and its precursors have a variety of source categories in the region, including industrial emissions, vehicular emissions, and cross-border transport form Mexico. Although recent data show a decline in the frequency of high ozone events, $PM_{2.5}$ levels in the region continue to surpass the daily standard of 35 µg/m^3. With the recent reduction of the National Ambient Air Quality Standards (NAAQS) for annual average $PM_{2.5}$ down to 9 µg/m^3, understanding the composition and sources of particulate matter has become crucial in avoiding non-attainment status. Exposure to elevated levels of particulate matter can lead to respiratory problems, cardiovascular diseases, and even premature death, which underscores the importance of air quality monitoring in the region to guide strategies aimed at maintaining compliance with federal regulations and safeguarding public health.

In a recent two-week field campaign conducted in January 2025, we measured mixing ratios of volatile organic compounds (VOCs) and fine particulate matter (<1 micron), using an electric mobile van equipped with a Vocus 2R Proton Transfer Reaction Time-of-Flight Mass Spectrometer (Vocus PTR-TOF-MS) and a High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) in the El Paso area. Preliminary findings reveal hotspots for different pollutants from various source types and industries. For example, ethylene oxide enhancements were encountered downwind sterilization facilities in the area, as well as elevated aromatics levels near a local refinery. Traffic emissions, mostly from diesel engines, contributed to sudden, significant spikes in organic aerosol levels near major roads. We will present a comprehensive summary of the observations made and results from source apportionment that provide insights into the sources of primary and secondary gas and particle-phase pollutants in the area.

Using Ambient Concentration Measurements to Quantify Volatile Organic Compound Emissions from Unconventional Oil and Gas Operations

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Oil and gas (O&G) development in the U.S. has accelerated in the past two decades, aided by unconventional extraction techniques, including horizontal drilling and hydraulic fracturing. Potential environmental and health impacts of volatile organic compounds (VOCs) originating from O&G activities have raised concerns, but emission estimates remain highly uncertain, hindering accurate environmental assessment. This study offers new insights into operation-specific VOC emission rates during unconventional O&G development (UOGD).

We utilize dispersion model simulations with an emission inversion method to analyze four years of weekly air canister samples, measuring 50 VOCs at 10 monitoring sites in Broomfield, Colorado where several large multi-well pads were drilled, completed, and entered production. Emissions are characterized from well drilling, hydraulic fracturing, coiled tubing/millout, flowback, and production operations. Substantial variations in average VOC emission rates are observed across different UOGD operations. Drilling and coiled tubing operations exhibit the highest total VOC emission rates, attributed to drilling mud volatilization and hydrocarbon release from underground shale formations. Our findings provide the first report of VOC emissions from coiled tubing/millout operations. Hydraulic fracturing operations had much lower emission rates, derived mainly from fracking engine emissions. In prior work studying green completions, Hecobian et al. (2019) found the greatest emissions during flowback operations.

The closed-loop, tankless flowback operations employed in Broomfield reduced average VOC emissions by 98% relative to that earlier work. We find that EPA's nonpoint oil and gas emission tool underestimates VOC emissions from drilling mud volatilization and flowback green completions. Production was characterized by lower VOC emission rates than pre-production operations but remains an important emission category due to its long duration (decades). Variations of emission rates within each operation highlight the complexity of factors and activities influencing emission rates, including, for example, vertical vs. horizontal drilling and periodic maintenance activities.

HEI

Investigating Impacts of Zero-Emission Truck Regulations on Tailpipe and Non-Tailpipe Air Pollutant Exposures and Health Risks in Southern California Communities

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Background and objectives: Heavy-duty truck emissions are one of the main contributors to air pollution in Southern California, disproportionately impacting communities along freeways and near seaports. We assess the impact of recently adopted zero-emission truck regulations on health risks in historically marginalized Southern California communities along freight movement corridors.

Methods: We develop an integrated modeling and community engagement framework for evaluating the air quality, health, and equity impacts of California's Advanced Clean Trucks (ACT) and Advanced Clean Fleets (ACF) regulations at the neighborhood scale. Specifically, we utilize newly available transportation big data for heavy-duty trucks to create a high-resolution air pollutant emissions inventory, covering tailpipe diesel $PM_{2.5}$ and NOx, and non-tailpipe brake and tire wear $PM_{2.5}$ and PM_{10} emitted from trucks. Using a sophisticated air quality model and established concentration-response functions, we will estimate the impact of regulations on PM, NOx, and O_3 concentrations, associated changes in mortality and morbidity, and monetized health benefits.

Results: We found that VMT per area in disadvantaged communities (DACs) (19,611 miles/ mile^2) is 2.2 times higher than in non-disadvantaged communities (8,733 miles/ mile^2). Similarly, total NOx and idling NOx emissions per area are also 2.6 times and 3.2 times higher in DACs as compared to non-DACs, respectively. We also analyzed county-level emissions reductions projected from California's ACT and ACF regulations. Adopting ACT and ACF will increase the penetration rate of zero-emission trucks from 0% in 2019 to 42% in 2045, contributing to NOx emissions reduction.

Conclusions: Our preliminary findings show that emissions are concentrated disproportionately in DACs. This study will advance community education and research capacity through collaborative partnerships and the development of interactive

Feasibility and environmental benefit of truck electrification unveiled by big operational data

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The electrification of trucks is a major challenge in achieving zero-emission transportation. However, the feasibility and environmental benefits of truck electrification remain uncertain due to the lack of real-world data on performance and energy consumption across different truck categories. This study addresses this gap by analyzing year-long operational records from 61,598 electric trucks (ETs) and over 55,000 diesel trucks (DTs) in China. We evaluate the feasibility, life-cycle NOx and CO_(2) emission reductions of electrifying nine truck fleets. Our findings reveal significant spatial heterogeneity in on-road CO2 and NOx emissions across different DT fleets. Comparing the usage patterns from DT and ET datasets, we identified current challenges for ET deployment related to their low usage intensity. 23% of electric delivery trucks and 30% of semi-trailers could achieve one-on-one replacement with diesel counterparts, while on average 3.8 and 3.6 electric trucks are required to match the transportation demand served by one diesel truck separately. Combined life-cycle modelling with real-world usage patterns, we identified that, for diesel trucks capable of one-to-one replacement, electric trucks have 1-49% and 51%-87% reductions for life-cycle CO_(2) and NOx emissions. Enhancements in usage patterns, vehicle technologies, and charging infrastructure can improve electrification feasibility and yield environmental benefits. Increased battery energy density with optimized usage can make one-on-one electrification feasible for over 85% of diesel semi-trailers. Additionally, with cleaner electricity, most Chinese electric trucks will have lower expected life-cycle CO_(2) emissions than diesel trucks in 2030. These insights shed lights on accelerating the transition to zero-emission freight transportation.